AD-A167 780 EVALUATION OF ALTERNATIVES FOR AN ARMY PRECISION LANDING SYSTEM(U) ARINC RESEARCH CORP ANNAPOLIS MD R LANCASTER ET AL. SEP 85 2959-01-1-3759 — 1/2

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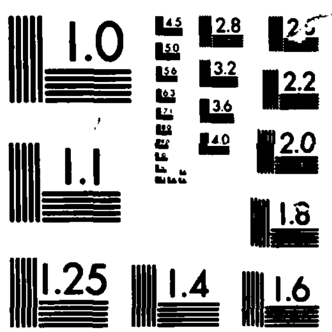

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ARINC Research Publication 2959-01-1-3759

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FINAL REPORT

EVALUATION OF ALTERNATIVES FOR AN ARMY PRECISION LANDING SYSTEM

September 1985

Prepared for
U.S. ARMY INFORMATION SYSTEMS COMMAND
U.S. ARMY AIR TRAFFIC CONTROL ACTIVITY
ATTN: ASQ-DD
FORT HUACHUCA, ARIZONA 85613-5380
under Contract DAEA18-84-C-0127
Tasks 1-4, CDRL Item A005
September 1984 - September 1985

ARINC RESEARCH CORPORATION

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER ARINC Research Corp. No. 2959-01-1-3759	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Evaluation of Alternatives for an Army Precision Landing System	5. TYPE OF REPORT & PERIOD COVERED Research Rpt & Study
	6. PERFORMING ORG. REPORT NUMBER Contract-ARINC Research Corp.
7. AUTHOR(s) R. Lancaster, R. Lewsen, B. Mitchell — ARINC Research Corp.	8. CONTRACT OR GRANT NUMBER(s) Contract No. DAEA 18-84-C-0127
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Air Traffic Control Activity ATTN: ASQ-DD Ft Huachuca, AZ 85613-5380	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 395114A (ATCA) (program element)
11. CONTROLLING OFFICE NAME AND ADDRESS Development Directorate USAATCA, ASQ-DD Ft Huachuca, AZ 85613-5380	12. REPORT DATE September 1985
	13. NUMBER OF PAGES 129
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Same as No. 9 above	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release, Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same as above.

18. SUPPLEMENTARY NOTES

DTIC Number DA 304796

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Precision Approach Radar, Precision Landing Systems, Radar Emission ATC Combat Support, Global Positioning System, Instrument Landing, Meteorological Conditions.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study was conducted to determine the need for Army Precision Landing System requirements for aviation deployment in the combat zone. The study identifies the need and best approaches for satisfying Army requirements within air traffic management functions, applying current tactical doctrine. Existing landing systems are compared with alternate systems not presently developed or

fielded from a technical and operational viewpoint. Availability, operational concepts, and cost data are analyzed for each proposed system. The study also developed strengths and weaknesses of the existing, as well as proposed precision landing systems for ATC. Final results and recommendations to support air traffic control requirements on the battlefield beyond the year 2000 are depicted.

Keywords: instrument landing; TMLS (Tactical Microwave Landing System)

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Publication 2959-01-1-3759

ABSTRACT

This report describes the results of ARINC Research Corporation's evaluation of alternative tactical precision landing systems in the context of current air traffic management functions. It presents the results of a comprehensive survey of Army precision landing requirements for the brigade area, identifies alternative systems, and evaluates those systems in terms of the identified requirements. Conclusions and recommendations regarding the alternative systems and problem areas are provided.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AACTS	Aircraft Approach Control Transmitting Set
AHIP	Army Helicopter Improvement Program
ALB	AirLand Battle
APLS	Army Precision Landing System
ASR	Area Surveillance Radar
ATC	Air Traffic Control
ATM	Air Traffic Management
AWLS	All Weather Landing System
BLS	Beacon Landing System
DME	Distance Measuring Equipment
DOT	Department of Transportation
DROC	Draft Required Operational Capability
FAA	Federal Aviation Administration
FAAO	Field Artillery Aerial Observer
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IMC	Instrument Meterological Conditions
JTMLS	Joint Tactical Microwave Landing System
LHA	Amphibious Assault Ship (general purpose)
LHX	Light Helicopter Experimental
LPH	Amphibious Assault Ship (helicopter)
LRU	Line Replaceable Unit
MADGE	Microwave Aircraft Digital Guidance Equipment
MICRAD	Microwave Radiometry
MLS	Microwave Landing System
MMR	Multi-Mode Receiver
MRAALS	Marine Remote Area Approach and Landing System
MTI	Moving Target Indicator
NDB	Non-Directional Beacons
NOE	Nap-of-the-Earth

GLOSSARY OF
ABBREVIATION AND ACRONYMS (continued)

O&O	Operational and Organizational
PAR	Precision Approach Radar
R&D	Research and Development
R&M	Reliability and Maintainability
RAC	Radiometric Area Correlators
SEMA	Special Electronic Mission Aircraft
TLS	Tactical Landing System
TMLS	Tactical Microwave Landing System
TRADOC	Training and Doctrine Command
TRSB	Time Reference Scanning Beam
UE	User Equipment
USAATCA	U.S. Army Air Traffic Control Activity
USAAVNC	U.S. Army Aviation Center
VMC	Visual Meteorological Conditions
VSTOL	Vertical and Short Take-Off and Landing

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CHAPTER ONE

INTRODUCTION

1.1 OBJECTIVE

The objective of this evaluation is to identify the best approach to satisfying the U.S. Army's tactical precision landing requirements within the context of air traffic management (ATM) functions and current tactical doctrine.

1.2 BACKGROUND OF TACTICAL PRECISION LANDING REQUIREMENTS

The U.S. Army is currently using the precision approach radar (PAR) portion of the AN/TPN-18 for precision landings. However, it is recognized that this aging radar does not provide the reliable landing service or the low signature required to avoid enemy exploitation in a tactical situation. Therefore, development of a small, low-power, portable tactical landing system (TLS) was initiated by U.S. Army Avionics Research and Development Activity (AVRADA), Ft. Monmouth, New Jersey, for the U.S. Army Communications Command (USACC), Ft. Huachuca, Arizona. After work on the TLS proceeded through the developmental stage and flight tests were successfully completed, the program was terminated because of increased cost and severity of threat. In addition, both the U.S. Army Training and Doctrine Command (TRADOC), Ft. Monroe, Virginia, and the U.S. Army Aviation Center (USAAVNC), Ft. Rucker, Alabama, believed that the tri-service Joint Tactical Microwave Landing System (JTMLS) would fill U.S. Army needs for a tactical precision landing system in the division rear. At that time, landing needs at locations forward of the division rear either would be filled by JTMLS or, because of technological developments by the threat, would be left unfilled.

The JTMLS program transitioned into the current Tactical Microwave Landing System (TMLS) program. The Army is circulating a draft required operational capability (DROC) for the Army Microwave Landing System, which will be the Army version of the TMLS. TRADOC plans to employ the TMLS only at division rear landing sites, thus leaving unfilled the requirements for precision landing systems forward of the division rear. Under Contract DAEA18-84-C-0127, ARINC Research Corporation conducted a study to

review Army requirements for a precision landing system, then to identify and evaluate alternative systems, and finally to identify and document the best approach to satisfying the near-, mid-, and long-term requirements. The definition of a precision landing system for the purposes of this analysis has been broadened to include the use of guidance from other than a ground-based system. It does not exclude systems employing a classical glide-slope solution.

The Instrument Landing System (ILS) will be replaced eventually by the civilian MLS or military TMLS. These systems are depicted in Figures 1-1 and 1-2 to clarify the limitations of this Army Precision Landing System (APLS) study. The figures portray the two different beam-type landing approach patterns. We investigated the need and identified requirements for a landing system that would support the hardware and procedural needs identified in Sector B of these figures. We did not include functional requirements of Sectors A or C as part of the landing system requirement. Deconfliction and separation control in Sectors A and B are also not a requirement of this task; however, deconfliction and separation control are discussed in Appendix D, Section 4, as they pertain to the APLS concept.

This report covers the contract period 29 September 1984 through 30 September 1985.

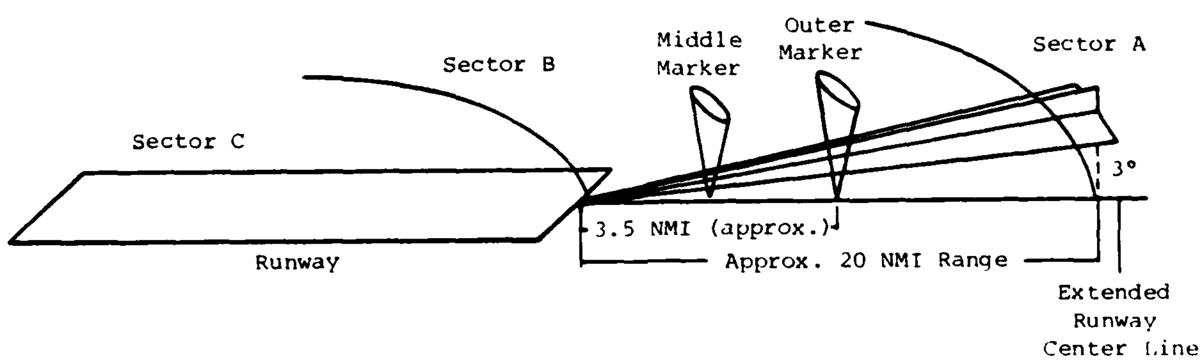


FIGURE 1-1

INSTRUMENT LANDING SYSTEM

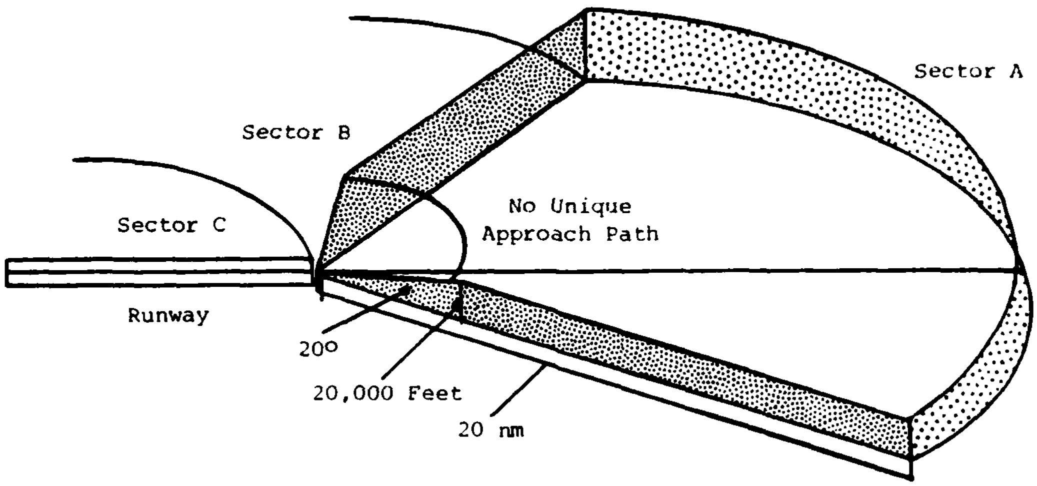


FIGURE 1-2

MICROWAVE LANDING SYSTEM

1.3 EVALUATION

In conducting our evaluation, we addressed the following four tasks as called out in the contract Statement of Work:

- Review Army requirements
- Identify alternative systems
- Evaluate alternative systems
- Identify and document best approach

1.4 REPORT ORGANIZATION

Chapter Two provides a review and determination of Army landing system doctrine and requirements. Chapter Three addresses the precision landing system requirements. Chapter Four identifies alternative systems. Chapter Five is an evaluation to determine the near-, mid-, and long-term approaches to meeting the precision landing system requirements. Chapter Six presents conclusions and recommendations.

Appendix A is the organizational and operational plan for the OH-58D helicopter. Appendix B lists military organizations visited and personnel interviewed. Appendix C is a scenario analysis used to quantify IMC landing requirements. Appendix D presents backup data on precision landing system requirements. Appendix E presents study background data. Appendix F lists current precision and nonprecision avionics. Appendix G is a discussion of the four most critical parameters used as system discriminators in the selection process.

CHAPTER TWO

ARMY LANDING SYSTEM DOCTRINE AND REQUIREMENTS

2.1 OVERVIEW

The technical approach to determining Army Precision Landing System requirements is to determine if there is a need for a landing system and, if there is a need, what the system must accomplish. To establish such a need, an investigation of tactical doctrine was initiated, employed doctrine was discussed with users, and a scenario analysis was performed to determine quantitatively the existence of a tactical approach and landing requirement. The following sections describe the results of this analysis in defining the need for the landing system.

2.2 TACTICAL DOCTRINE

The concepts, doctrine, and training used by the U.S. Army in combat, and in the supplying and reconstituting of forces are undergoing major changes. Studies such as Division 86, AirLand Battle and Corps 86, Army 21, and the Army of Excellence not only are influencing procurements and training plans for the future but have spurred the Army to make changes now.

TRADOC Pamphlet 525-5, U.S. Army Operational Concepts, The AirLand Battle and Corps 86, 25 March 1981, addressed high-speed action and reaction in response to enemy targets of opportunity. By directing deep attacks on enemy forces, the commander of a corps, for example, opens a window of opportunity in an area to be reached in the next few hours by division offensive forces.

The concept of rapid, coordinated actions to exploit targets of opportunity is vital in defeating the numerically superior Warsaw Pact forces. Such a concept requires both aircraft that can operate in all-weather day-or-night conditions and landing systems that will permit operation in such conditions.

In concert with the AirLand Battle (ALB) doctrine, and in keeping with future concepts of rapid, dependable troop, supply, and attack movement by helicopter, the U.S. Army is attempting to provide aircraft and systems that will facilitate safe flying in all weather conditions and at night. Table 2-1 cites several sources that document all-weather

requirements for each platform type. The Special Electronic Mission Aircraft (SEMA) must provide intelligence at all times regardless of the weather. The threat must not be given the luxury of operations in bad weather totally concealed from SEMA aircraft. The Operational and Organizational (O&O) plan for the Light Helicopter Experimental (LHX) states that the LHX "...will be capable of conducting nap-of-the-earth operations continuously throughout the entire battlefield..." Also, the LHX will "...perform its missions continuously in adverse weather and over all terrain."

Another example of documented requirements is the O&O Plan for the OH-58D, or Army Helicopter Improvement Program (AHIP). The OH-58D is in production, and the first aircraft are being delivered now. The O&O plan states, "The scout helicopter must be capable of performing in day/night or adverse weather." Also, "A need exists to navigate accurately in a nap-of-the-earth (NOE) environment...". The OH-58D mission profiles and the operational mode summary further document an all-weather requirement. These are listed in Appendix A. All flights are listed as flying at contour flight levels or lower, and the wartime operating time per year averages 6.0 hours per day per aircraft (2200 hours per aircraft per year in non-desert environment in a Field Artillery Aerial Observer [FAAO] role).

Our conclusion from summarizing these data is that Army doctrine requires aircraft capable of flying at very low altitudes over all terrain, during day and night, and in adverse weather, and that instrument meteorological conditions approaches to landings will be required.

Visual meteorological conditions (VMC) are conditions expressed in terms of visibility, cloud distance, and ceiling equal to or better than the specified minimum. Instrument meteorological conditions (IMC) are conditions expressed in terms of visibility, distance from cloud, and ceiling lower than the minimum specified for VMC. Instrument landing categories are:

Category*	Ceiling (feet)	Runway Visibility (feet)
I	200	2600
II	100	1200
III A	0	700
III B	0	150
III C	0	0

*Typically the categories are referred to as "200 and 1/2," or "100 and 1/4," but the actual parameter for runway visibility is in feet.

Source: Federal Navigation Plan, DoD (OUSDRE) and DoT (DMA-26), DoD-4650.4, Dec 84, Page II-16

TABLE 2-1

WEATHER REQUIREMENTS FOR ARMY ROTARY WING PLATFORMS

Platform	Requirements	Source
SEMA	Day and night; all weather	QUICK FIX ROC, December 1984
Light Helicopter Experimental (LHX)	Day and night; adverse weather capabilities mandatory	O&O Plan (Draft), 6 March 1985
Supply Helicopters	Day and night; all weather	Ft. Eustis Transportation School, Concepts and Studies Branch
OH-58D	Day and night; adverse weather, marginal visibility	O&O Plan, March 1985
Advanced Cargo Rotorcraft (ACR)	Climatic zones 1 through 8, same weather profiles as OH-58D; "respond to time-critical emergencies"	O&O Plan (Draft), undated

2.3 EMPLOYED DOCTRINE

ARINC Research visited cognizant activities and interviewed knowledgeable personnel as part of its survey of employed doctrine and precision landing system requirements. Selected activities visited and personnel interviewed are listed in Appendix B. Table 2-2 summarizes our understanding of the overall requirements, based on these interviews. HQ TRADOC, its centers, and its schools have not hypothesized landing systems forward of the division rear. Further, HQ TRADOC and HQ USAAVNC stated that recovery-interval control and separation control in the brigade area are <u>not</u> considered requirements, because of the probable threat exploitation of systems providing these functions.

During the interviews, several organizations (see Table 2-2) stated that there should be no emitting landing systems forward of the division rear. However, other organizations expressed a need for forward-area landing systems. Several of the commands interviewed desired a passive system -- that is, one that requires no transmissions in the forward area.

either from the aircraft or from a forward ground system. This is a sensitive issue, influenced primarily by the abilities of the threat and how those abilities are perceived by each organization. Most discussions were centered on VMC conditions, which do not require a precision landing system. Opinions concerning flying in IMC conditions can be summarized as follows: we are not planning to fly in IMC forward of the division rear; we would return to our last VMC location if unable to maintain VMC; and we would land and wait for at least marginal VMC conditions. Primarily, the attitude was that the pilots would not fly in IMC, no matter what the doctrine says. The pilots state that they are not trained to fly these forward-area, low-altitude missions in IMC, and there are no landing systems available in the environment to complete these missions.

2.4 DOCTRINAL DICHOTOMY

Doctrine as summarized suggests that helicopters will fly very low (contour or NOE) altitudes over all terrain during both day and night or in adverse weather. This implies flying and landing in both VMC and IMC. VMC landings without a precision landing system are routine; however, an aircraft cannot make a safe approach to a landing in IMC conditions without an adequate landing system. Further, at Category II approach minimums (100 and 1/4) a helicopter must be in a position from which a safe hover and landing can be made. It is implicit that a precision landing system is required for an IMC approach.

Employed VMC doctrine is in agreement with present flying procedures. Employed IMC doctrine is dichotomous with documented doctrine. Helicopter pilots in general do not expect to be flying or landing in IMC forward of the division area.

2.5 SCENARIO ANALYSIS RESULTS

Our perception of the situation is that a precision approach landing system should be available for missions that will be required under IMC. A special scenario analysis was performed to quantify the number of potential IMC landings. This analysis is presented in Appendix C. In summary, the scenario analysis estimated the requirement for approximately 55 IMC landings in the brigade area per day and a larger number in the division rear (averaged from a three-day scenario). This quantity could not be supported by substitution, e.g., motor transport (MT) or "time out" in a combat scenario. IMC landings are required in the brigade area and must be supported.

2.6 SUMMARY

There is disagreement between doctrine and operational practice regarding the need to land helicopters in both the division and the brigade areas in IMC as dictated by doctrine and supported by the scenario

TABLE 2-2

REQUIREMENTS FOR TACTICAL ARMY PRECISION LANDING SYSTEM, BASED ON INTERVIEWS*

Organization	Type of Mission	Synopsis of Requirement
I.. Rucker and Ft. Monroe	Scout/Attack	Prefer autonomous systems, with no transmissions. Need all-weather, night capability for helicopters at about 400- to 500-foot altitude in division rear at two instrumented landing sites. Enemy threat makes low power and a service demand mode imperative. Category II landings (100-foot ceilings and 1/4-mile visibility) are required. Recovery interval control and aircraft separation are not requirements, in light of the threat exploitation of these systems.
Ft. Rucker, Ft. Lee, Ft. Leavenworth, and Ft. Eustis	Transport/Logistics/ Joint Air Drop	Same as above, plus possible landings of USAF C-17s and C-130s, probably controlled by USAF teams.
Ft. Huachuca and Ft. Rucker	SEMA/Air Traffic Control	Day or night recovery in all weather. Traffic control and separation required.
Scott AFB	Joint Airlift	No impact on Army requirements; USAF handles these missions. Military Airlift Command (MAC) Combat Control Team (CCT) is responsible for the short term, generally less than three days; and the Air Force Communications Command is responsible for the long-term missions and fixed bases. TMLS will be used when it is fielded.
Ft. Sam Houston	Medical Evacuation (MEDEVAC)	Day and night, any weather; guidance to and landing at MEDEVAC site in any area of the battle zone.

*The requirements are for safe approach and landing at tactical sites; air traffic control (ATC) of the area between sites is not included.

analysis presented in Appendix C. VMC does not require a precision landing system; however, IMC does. Safety is paramount, and avoiding the loss of personnel and equipment necessitates the use of a precision landing system. Chapter Three addresses the specific landing system requirements.

CHAPTER THREE

PRECISION LANDING SYSTEM REQUIREMENTS

It is evident from the written doctrine and the interviews with operational personnel that there is a significant dichotomy between the helicopter flight as it is now performed or trained for and helicopter flight as envisioned in support of AirLand Battle (ALB). Presuming that this dichotomy will be resolved in favor of flight in IMC as well as VMC in support of ALB, and considering the results of the special scenario analysis of Appendix C, we determined requirements for a precision landing system in the brigade area. We conducted studies to review the possible key factors that describe the Army Precision Landing System (APLS). These have been grouped into four categories: Technical, Operational, Programmatic, and Technical Air Traffic Management factors required for APLS operation. These factors are summarized in Table 3-1, together with their requirements and a brief rationale. Appendix D presents expanded rationale for most of the factors. Background data pertaining to the APLS requirements are provided in Appendix E, which includes discussion of precision/nonprecision landings, division horizontal and vertical profiles, typical missions in the combat zone, the proposed APLS Concept of Operation, and the types of landing sites. Appendix F lists current helicopter precision and nonprecision avionics.

TABLE 3-1

PRELIMINARY REQUIREMENTS FOR ARMY PRECISION LANDING SYSTEM

Factor (Appendix D Supporting Data)	Requirement	Rationale
Technical		
Landing Category	Permit approach and landing down to IMC Category II (100-foot decision height and 1/4-mile visibility).	To support possible large number of landings resulting from weather or battlefield obscuration. CAT II was chosen because it specifies a 100-foot ceiling. (CAT I provides for a 200-foot ceiling. Most helicopters fly as low as possible, but most likely under 200 feet, if feasible in view of the threat implication.)
Maximum Slant Range (Paragraph 2)	At least 5 but not more than 10 kilometers.	With Front Line of Troops (FLOT) 10 to 30 kilometers away from the APLS site in the brigade area, the maximum range of 10 kilometers was selected to decrease exploitability.

(continued)

TABLE 3-1 (continued)

Factor (Appendix D Supporting Data)	Requirement	Rationale
Glide Slope Elevation (Paragraph 2)	Glide slope adjustable between 0° and 10° in 0.1° increments.	Limits were selected to keep beam as low as possible to avoid extremely high aircraft deceleration rates during approach. Lower limit is critical since most helicopters are flying at very low altitudes.
Azimuth (Paragraph 3)	Azimuth adjustable $\pm 10°$ to $\pm 20°$ in 2° increments.	Azimuth limits were kept small to decrease exploitability. Could be narrower with procedures providing a precision feeder point.
Environment (or weather effects)	Be capable of operating in same weather conditions as combat unit aviation assets: rain, fog, dust, snow.	If helicopters are required to operate in climatic zones 1-8, the APLS should also be.
Setup and Alignment (Paragraph 5)	No more than 30 minutes by two men under nuclear, biological, and chemical (NBC) conditions.	NBC conditions represent the most severe conditions in which men will operate. Two men were selected because, in combat, crews will probably not be 100 percent filled. Thirty minutes was selected to provide a maximum of operational time during the 6 to 8 hours a site is operational in the forward area (excluding travel time and system outages).

(continued)

TABLE 3-1 (continued)

Factor (Appendix D Supporting Data)	Requirement	Rationale
Operational		
Susceptibility (Paragraph 6)	Passive operation preferred; demand mode if active; GHz frequencies.	Passive preferred over active because of possibility of exploitation. If a system (airborne or ground-based, or both) is active, the system should include demand mode. Higher frequencies are preferred.
Deployability (Paragraph 5)	System and crew with APLS fit in utility helicopters or 5/4-ton truck; no module should require more than a two-man lift.	Sizing dictates the use of a utility helicopter (or 5/4-ton truck if no helicopter is available). Lifting should require a minimal number of men, since the ground system may be moved frequently every day.
Interoperability (Paragraph 7)	Should operate with programmed systems in the division and CONUS. System must also be interservice-compatible.	Multiple-location use i.e., from the battlefield through to bases or airfields in the CONUS. Multiple different avionics or ground system packages are not desired.

(continued)

TABLE 3-1 (continued)

Factor (Appendix D Supporting Data)	Requirement	Rationale
Training Requirements	Two levels of expertise: a. Operator/unit maintenance -- capable of isolating a fault with BITE and replacing LRU. b. Direct support [or Aviation Intermediate Maintenance (AVIM)] -- should be an add-on skill identifier for present AVIM Military Occupational Specialties (MOS).	System must be user-friendly and easily and quickly repaired.
Personnel Impact (Paragraph 5)	Three- to five-man sections, self check, fault detections sent to remote unit.	System must be small and permit one man to operate from a remote station to enhance crew survivability. Section consists of 2 one- or two-man shifts plus a supervisor.
R&M (Paragraph 8)	MTBF (ground site): 1,000 hours; MTTR: less than 30 minutes at the organizational level, airborne avionics-compatible.	Provide very high availability (A_i = 99.9 percent) to ensure balance between maintainability and operations without probable requirement for redundancy. MTTR should be low to ensure that the system will be available approximately 80 percent of the time if there is a failure.

(continued)

TABLE 3-1 (continued)

Factor (Appendix D Supporting Data)	Requirement	Rationale
Ancillary Equipment (Paragraph 8)	None preferred; battery-operated (auxiliary power operation optional); no test equipment (use BITE).	Because of deployability requirements and crew size, additional equipment must be minimized.
Programmatic		
System Availability (Paragraph 8)	$A_i = 0.999$	See rationale for R&M.
Commonality (Paragraph 9)	Ground systems should be modular. Tactical forward area ground systems should be essentially identical and interchangeable with CONUS-based systems.	Provides for lowest costs associated with logistics, personnel training, and special R&D.
Useful Life	20 years desired.	Systems should provide sufficient life to permit planned low-cost evolution to future passive systems and possible product improvements.
Affordability (or cost) (Paragraph 10)	Ground system should be low-cost and technically low-risk; it should operate with current or planned aircraft landing system avionics (e.g., ILS, MLS, GPS,) if possible.	Systems should be available in the near term with minimal R&D required (minor redesign and repackaging of current technology). Should use current landing system signal formats to permit use of

(continued)

TABLE 3-1 (continued)

Factor (Appendix D Supporting Data)	Requirement	Rationale
Affordability (or cost) (Paragraph 10) (continued)		existing or planned landing avionics. Costs for the ground system should be low enough to provide for sufficient quantities on the battlefield.
Technical Air Traffic Management		
Separation Capabilities (Paragraph 4)	Keep aircraft approximately 4500 feet apart.	Aircraft at 90 knots recovering at 2 aircraft per minute would have 4500-foot separations.
Recovery Intervals (Paragraph 4)	2 aircraft per minute.	MAXFLY scenario utilized less than 0.25 aircraft landing per minute in a brigade area for a three-day period. Two aircraft per minute provides for a maximum surge capacity.
Maximum Number of Aircraft That Can Be Handled (Paragraph 4)	6 to 8 aircraft in the 10-kilometer range of APLS at any given instant.	In a sequential landing, the number of aircraft would be approximately 7.0, based on 30-second recovery interval and separation capabilities.

CHAPTER FOUR

IDENTIFICATION OF ALTERNATIVE SYSTEMS

4.1 SYSTEM OVERVIEW

The systems considered as candidates for fulfilling the requirements of Chapter Three were identified from several sources. Table 4-1 lists the systems and types of operation. There are many other systems, such as the USAF TALAR by General Precision and the Bell SAILS, which were developed but not approved for production. We did not consider all of these older systems, since they were previously rejected as too complex for tactical use or were replaced by the MLS program. The systems examined included all general types that are operational, developmental, experimental, and even previously canceled systems. They are described in the following sections. In Chapter Five we evaluate those systems against the requirements described in Chapter Three.

4.2 TECHNICAL SUMMARIES

Table 4-1 lists each system, its status, and its type of operation. Each system is described in some detail, with emphasis on how actual landing data are provided.

4.2.1 AN/TPN-18

The AN/TPN-18 radar is a 1960s AN/TPN-8 modified to include an AN/TPX-44 IFF. The radar provides area surveillance radar (ASR) and precision approach radar (PAR) but does not have a moving target indicator (MTI). Since MTI provides easier target recognition and is standard for Air Force, Marine Corps, Navy, and FAA radars, a program is now approved to provide new shelters and MTI for the TPN-18 by about 1989. PAR approaches are provided by radio communication from an ATC controller to the pilot. Aircraft recovery intervals and separation distances are also easily handled by ATC controllers.

The AN/TPN-18 radar employs a pulsed signal with 200 kilowatts of peak power to ensure an adequate return signal. A disadvantage of the high power is its ease of exploitation. This radar has exacting setup

TABLE 4-1

CANDIDATE APLS

System	Status	Type
AN/TPN-18	Operational	High-Power Radar
Tactical Landing System (TLS)	Developed/Canceled	Microwave Scanning Beam
Tactical Microwave Landing System (TMLS)	Developmental	Microwave Scanning Beam
Marine Remote Area Approach and Landing System (MRAALS), Ground Portion, AN/APN-30	Operational	Microwave Scanning Beam
Multi-Mode Receiver (MMR)	Developmental	Beam Position (This is avionics only. Uses ILS, MRAALS, MLS ground system.)
Global Positioning System (GPS)	Developmental	Trilateration (Satellite, Position Only)
Microwave Aircraft Digital Guidance Equipment (MADGE)	Operational	Microwave Interferometry
Beacon Landing System (BLS)	Experimental	Fixed Beams
Radiometric Area Correlators (RAC)	Experimental	Passive Energy Reception and Mapping

and test procedures. The AN/TPN-18 weighs 3600 pounds and takes 15 man-hours to install. Although other services are pursuing the development of new GCA radars, the Army believes that this type of radar is not survivable in the front lines of a sophisticated combat theater.

4.2.2 Tactical Landing System (TLS)

A prototype of the TLS was developed by the AIL Company in 1975 and reduced to a portable unit by 1982. The TLS provides a Ku-band scanning beam that is interoperable with the MRAALS (USMC) and the AN/SPN-41 (USN). NASA has used and improved this system with the Shuttle program. It requires a receiver, antenna, and displays on the helicopter. The system also radiates 200 watts peak from the ground, much lower power than is emitted by the GCA-type radars. If a DME function is included, the aircraft also radiates. No separation or recovery intervals are provided.

4.2.3 Microwave Landing System (MLS)

In 1971, development of a new national/international standard MLS was initiated as a joint effort of the Department of Transportation (DOT), Department of Defense (DoD), and National Aeronautics and Space Administration (NASA). The Federal Aviation Administration (FAA) was designated the lead agency. The goal of the program was to develop and acquire a common civil/military precision aircraft approach and landing system incrementally capable of providing fully automatic approach and landing guidance down to International Civil Aviation Organization (ICAO) Category III (zero decision height) minimums. The program progressed through the concept definition, feasibility, and engineering prototype development and demonstration phases. The system concept selected for MLS angle guidance was based on the use of a time reference scanning beam (TRSB) technique, which was selected in 1978 by ICAO as the new international standard MLS technique.

The civil MLS ground and airborne equipment, now in the initial production phase, will be used in some, but not all, military applications. An initial DoD MLS implementation plan was developed and initiated in 1977. The Army was designated the lead DoD agency for the first phase of the program, which was limited to development and acquisition of Joint (tri-service) Tactical MLS (JTMLS) ground and airborne equipment. Because of funding problems, the JTMLS contract awarded to the Bendix Corporation and Bell Aerospace was canceled in August 1981. In January 1983 the Air Force became the lead service for all DoD MLS activities, including the development and acquisition of JTMLS ground equipment [with the current nomenclature of AN/TRN-XX(V) and designated the Tactical Microwave Landing System (TMLS)]. This is the system we examined. The Air Force program is planning to take full advantage of previous FAA-sponsored and Army military system design studies and the current availability of applicable FAA standards and specifications that must be met by all military MLS equipment configurations to ensure civil-military MLS interoperability.

The Army is currently circulating for review a draft required operational capability (DROC) for the Army Microwave Landing System. This may result in Air Force and Army purchases of the same ground MLS units. By use of a C-band scanning beam and avionics in the helicopter, the azimuth and glide slope are presented to the pilot for landings down to CAT II

minimums. No separation or recovery intervals are provided, and a separate L-band precision DME is required for distance to landing. Table 4-2 lists those Army helicopters selected for TMLS and GPS receiver installation.

TABLE 4-2

PLANNED GPS AND TMLS ROTARY-WING PLATFORMS

GPS	TMLS
AH-1S, AH-64A, OH-58D	Scout and attack helicopters, including LHX
EH-60A	SEMA (EH-60, EH-1)
UH-60A	Utility (UH-60, UH-1) plus the joint-service V-22 Osprey
CH-47D	Cargo (CH-47)

There apparently has been no approved quantitative study to determine the number of avionics systems required for the Army, although the DROC for TMLS states: "The number of aircraft ultimately equipped with TMLS is estimated at approximately 4,500, plus a portion of the scout and attack helicopters fleet (exact number to be determined)." The determination of this number is beyond the scope of this study; however, our observations tend to support equipping all helicopters in the tactical arena as a minimum, in addition to the requisite training helicopters. The projected total is greater than the estimated 4,500.

4.2.4 Marine Remote Area Approach and Landing System (MRAALS)

The MRAALS program was initiated by NAVELEX in 1972 as a competitive advanced development program for a tactical landing system to meet the Marine Corps requirement to land at remote area landing zones in IMC conditions. The principal requirements were that the MRAALS provide a signal-in-space duplicating the shipboard AN/SPN-41 independent landing monitor (ILM), include a distance measuring equipment (DME) transponder capable of supporting a ±100-foot system error, and be man-transportable in design and weight.

MRAALS utilizes the ground-based AN/TPN-30 AACTS (Aircraft Approach Control Transmitting Set) and an associated airborne suite of avionics. The AN/TPN-30 is a relatively high-energy, highly mobile instrument guidance system designed to allow Marine Corps helicopters and VSTOL (Vertical and Short Take-Off and Landing) aircraft to perform precision approaches into remote zones. The program includes the adaptation of the MRAALS for use on the LHA and LPH classes of amphibious assault ships as an independent landing system. The airborne subsystem evaluated in 1979-1980 was the AN/ARN-128 AWLS (All Weather Landing System). A subsequent Marine Corps decision was made to substitute the AN/ARN-138 MMR (Multi-Mode Receiver), described in the next subsection, for the AN/ARN-128. Since the initial operating capability (IOC) for the MMR is not expected to occur until 1989, MRAALS is not currently considered an operational system capable of Category II precision approaches to remote area landing zones. Some Naval Aviation fixed-wing aircraft have used their on-board ILS/AN/ARA-63A (Instrument Landing System) with the AN/TPN-30, but this ILS system is limited to glide slope, azimuth, and DME information. The MMR will transmit the required definitive landing zone information to the aircrew, (e.g., obstruction information, site configuration, offset-to-touchdown).

4.2.5 Multi-Mode Receiver (MMR)

The objective of the NAVAIR Multi-Mode Receiver (MMR) avionics program is to equip Navy and Marine Corps aircraft with a landing guidance receiver that will operate with the ship's AN/SPN-41, the shore-based ground equipment for the Marine Corps MRAALS, the ICAO ILS, and the ICAO MLS. It is now in development and will proceed into technical evaluation beginning in FY 1987. Existing aircraft will be retrofitted with the MMR, replacing the AN/ARA-63. MMR is specified to provide performance identical to that of the MLS avionics, ICAO ILS avionics, AN/ARN-128, and AN/ARA-63 when operated with the corresponding ground subsystem. The IOC is now set for 1989. The pilot selects the receiver front end that is to be used: VHF for ILS marker beacon and localizer, UHF for ILS glide slope, C-band for MLS, or Ku band for MRAALS. This special receiver is, of course, more costly and complicated than single-frequency-band receivers, but it would permit Army aircraft to land at current ILS-equipped fields, at future MLS-equipped fields, and at MRAALS- or MLS-equipped forward area landing sites.

4.2.6 Global Positioning System (GPS)

The NAVSTAR Global Positioning System is a space-based radio-positioning, navigation, and time-transfer system that operates on two L-band frequencies. It comprises three major segments: space, control, and user. Only the Army requirements for the user segment are included here; the space and control segments are being budgeted and funded by the Air Force as separate but related programs.

The space segment will be composed of 18 satellites plus three active spares in six orbital planes arranged so that a minimum of four satellites will be in view to any user. They will operate in orbits approximately 10,900 nautical miles high and should all be in place by 1989.

The control segment will include a master control station, monitor stations, and upload stations located throughout the world. Monitor stations will track all satellites in view and accumulate ranging data. The master control station will process the data to determine satellite orbits, and the updated information will be transmitted to the satellites via the upload stations.

The user segment will consist of the user equipment (UE) sets, which will use data transmitted by the satellites to derive navigation and time information. The GPS UE will be integrated into various aircraft navigation systems.

The mission of the Army UE portion of the GPS is to provide Army tactical forces with accurate positioning and velocity data in three dimensions and with precise time. Within the division, the GPS UE will be used to support operations for which passive position location is required. Table 4-2 listed Army helicopters selected for GPS installation.

Although GPS was not originally designed to be used as a landing system, it can be tailored to serve that function because of its inherent accuracy in three dimensions. Two concepts employing ground equipment to provide off-board landing information -- the differential GPS and the pseudolite GPS -- are possible candidates for a time precision landing system, but both require development to serve the needs of the APLS requirement for the tactical battlefield landing scenario. Therefore, they are possible candidates for a second-generation APLS. Differential GPS employs an accurately placed (surveyed) ground unit that calculates, in real time, the difference between its position and the GPS satellite's derived location. This difference is transmitted to the aircraft, where the data can be used to provide the navigation solution for the landing. Current limited testing of the differential GPS concept shows vertical accuracies on the order of three meters.* The pseudolite concept emulates a ground-based "satellite," thereby providing positioning information relative to the point of origin. Technical approaches to improving pseudolite capabilities are currently under development.

Probably the nearest-term capability to provide "precision" landing information via GPS in a tactical battlefield environment is in the use of on-board GPS navigation between selected waypoints, one waypoint being the initial point for approach and a second being the intended landing point. The major risk in this concept is the need to ensure a cleared area along

*GPS Differential Navigation Tests at the Yuma Proving Ground, L. R. Kruczynski, June 1985.

the selected approach zone. A ground site may require survey with sighting instrumentation (such as aiming circle, theodolite, or transit) to select a clear approach zone from the landing point outbound and to thereby develop waypoints for the landing solution.

4.2.7 Microwave Aircraft Digital Guidance Equipment (MADGE)

The British MADGE operates in C Band; it comprises a three-antenna ground set and an avionics suite of five boxes, two indicators, and one antenna. The angle of incidence of signals received from the aircraft is measured, coded, and sent up to the aircraft display at 150 watts, peak. This operation is done for azimuth, and then by an orthogonal antenna, for elevation. Range is also measured by the airborne unit, calculating the time elapsed between the transmission of the interrogation and the receipt of a valid reply.

The MADGE system fills NATO specifications for a portable tactical aircraft approach aid. The Royal Navy is outfitting its carriers, land training bases, and tactical mobile forces with MADGE, and the Italian Army is also using a MADGE for tests.

4.2.8 Beacon Landing System (BLS)

The NASA Beacon Landing System operates at 9400 MHz, or X band. The two ground-based antennas sequentially radiate four beacon replies, directionally oriented above, below, to the left, and to the right of the desired glide slope. A receiver and antenna in the helicopters detect these four signals, and the weaker signals are used to drive ILS-type displays to indicate corrective action to the pilot. The X band weather radar receiver is standard in Air Force aircraft. The ground unit is very portable and easily reoriented to another approach azimuth. Of special note concerning the BLS is the minimum elevation. In order to obtain the 2-degree elevation, metal fencing must be installed 50 to 100 feet in front of the BLS antenna. This reduces the ground-reflected portion of the down beam, prevents multipath reflections, and permits the helicopter to receive a clear "down" signal.

4.2.9 Radiometric Area Correlators (RAC)

As early as the 1970s, the Naval Weapons Center, China Lake, California, conducted very successful microwave radiometric experiments. Passive microwave radiometry (MICRAD) equipment has provided excellent images through dense cloud cover. A radiometer is an extremely sensitive receiver that senses thermal microwave (36 or 94 GHz) radiation emitted by and reflected from terrain features. RACs compare MICRAD data with a digitized map of the same area. All-weather, day-or-night capabilities have been proven, and two companies have done a great deal of work on this concept. Lockheed worked from 1966 to 1977 in the open on RACs, then in classified areas from 1977 to 1982. From 1982 through 1983, Lockheed developed RACs for use in advanced cruise missile system guidance. The

company is now developing its own landing system; in-house testing is planned for 1986. Sperry also has done some work on a MICRAD helicopter landing system, including tests in bad weather at the Army Missile Command.

The RAC system could be used in either of two ways. The picture observed could simply be displayed to the pilot as the aircraft comes down through the clouds, showing what is below and just forward. Alternatively, an on-board computer could have a digitized picture of the landing site. This would be compared with the actual MICRAD picture, and necessary approach corrections would be given on ILS-type indicators. Since the basic sensor R&D work is complete, this passive application is of interest for Army landing guidance. Of course, unless coupled to independent vertical (glide slope) information, this system must be considered nonprecision.

Figure 4-1 depicts how well the RACs work, even through complete cloud cover. The figure shows two photographs of Bakersfield, California, through 1500 feet of clouds from an aircraft at an altitude of 3500 feet. The first two strip photos show what the RAC system received, while the last strip is a normal photograph of the cloud cover. The RAC photos taken through the clouds, passively, clearly show details such as oil tanks, roads, and houses. The upper photograph clearly shows an airfield with runway, taxiways, and apron. At a lower altitude, more detail would be evident, even such items as trees and towers that might be hazards to landings. Although the RACs have not been applied to aircraft landings, they do have great promise as a landing system for use in IMC. This system should be further investigated by the Army. The problems that must be investigated include the angles of observation forward that are possible without distortion, methods of display, possible digitizing/ correlating, azimuth angle of coverage, and coupling to glide slope information.

4.3 SYSTEM DATA

Table 4-3 summarizes the system data for alternative APLS candidates. The RAC system, although considered a possibility in the long term, was not further considered, because of the unavailability of data. This summary table was previously presented to USAATCA during a briefing in which we addressed candidate systems. Chapter Five presents an evaluation of each system in relation to the requirements.

MICRAD

MICRAD

PHOTO

FIGURE 4-1

COMPARISON OF RAC SYSTEM PHOTOGRAPH WITH NORMAL PHOTOGRAPH

TABLE 4-3

SYSTEM COMPARISON MATRIX

Requirement	System							
	AN/TPN-18	TLS	TMLS	MRAALS	MMR	GPS	MADGE	BLS
CAT II	Yes	Yes	Yes	Yes	Depends on ground system	Yes, to flareout	Yes	Yes
Range	5 to 40 nmi	10 to 20 nmi	15 nmi	10 to 20 nmi	**	N/A	10 to 18 Km	17 nmi
Elevation	-1° to +10°	3° to 12° by 1°	2.5° to 15°	0° to 20°	**	N/A	1 to 45° (low power)	2° to 9° with fences
Azimuth	30° or 60°	±30°	±40°	±20°	**	N/A	±65° to 2 nmi ±45° out	±35°
Environment	All	All, even 25 mm/hour of rain	All	All	**	All	All	All
Alignment	Hours, Survey	10 min, 2 men	30 min, 2 men	10 min, 2 men	**	Differential link plus shelter survey	15 min, 2 men	5 min, 1 man
Susceptibility	Very easy to locate, jam, 200 kW peak	200 W peak demand mode	14 W, ICAO standard	4 kW peak	**	Link data not firm	150 watts passive unless interrograted	Demand, 400 W pulsed peak
Deployability	2-1/2 ton truck, 15 MH to install	3/4 ton truck, 2 units, 140# each	UH-1, Air droppable	UH-1 size	**	S-280 shelter	Land rover, helo	70 pounds
R&M	Ao still poor (41 - 75%)	BITE to LRU MTBF: 2000 hours	MTBCF: 6500 hours	MTBF of 2300 hours	MTBF: 1000 hours MTTR: 85 minutes max	MTBF: 1250 hours MTTR: 15 minutes	Min MTBF: 1100 hours (BITE) Max MTBF: 2020 hours	MTBF: 2,487 hours beacon, actual
Ancillary Equipment	Large power supply	Battery (8 hours) or generator	Generator	Generator	None	P.S. test set	Battery only	None
Cost	TBD	$200K, ground, 1982 $20K, air, 1982	$281K each ground $12K each air	$200-250K ground $24K each air	$50K avionics	$46-50K (1986) avionics	$300K each ground (1982) $70K each air (1982)	$50K ground (100 each) $7K air (1000 each)
Other					4 LRU, antenna indicators		Airborne: 5 LRU, antenna, 2 indicators	
Radio Frequency	9.0 - 9.6 GHz	Ku band	C band	Ku band	VHF/UHF/C band/Ku band	L band	C band	X band

*RAC systems not included.
**Depends on matching ground system (ILS, MLS, MRAALS).

CHAPTER FIVE

EVALUATION OF ALTERNATIVE SYSTEMS

5.1 APPROACH

Review of the candidate systems and the requirements for an APLS made it apparent that there is no operational system that will fully meet the requirements. From a production availability standpoint, therefore, we considered which system might be the best alternative in the following periods:

- Near Term - present to 1992. No new systems could be available and fully fielded much before 1992. This period also projects through the present Five Year Defense Plan.

- Mid Term - 1992 to 2000. Time for R&D to develop, test, and field a replacement system.

- Long Term - 2000 and beyond.

Since a number of systems meet some of the APLS requirements, we used a multi-attribute utility-analysis ranking and weighting technique to determine the best approach. The systems are ranked in relation to each requirement from a maximum of 7 for the best systems to 1 for the worst. This ranking scheme was selected solely because there are seven systems. (Two systems are not included in the evaluation: The MMR, since it is an avionics system now planned to be part of the MRAALS system; and the RAC due to unavailability of data.) If two or more systems are the same, they are each given the same value; for example, if two systems tie for the best, they are each given a 7; but a third (and lesser) system is assigned a value of 5. The factors as listed in Chapter Three were given weighted values of 1, 2, or 3 to emphasize their criticality, with 3 being the most critical (rationale discussed in Appendix G). Elevation and ground system cost were given weights of 2 to reflect the importance of very low-level approaches and ground system costs. Because of the Army's concern about susceptibility and the Congressional mandate for interoperability, these two requirements were given weights of 3. All other requirements were given weights of 1.

It is recognized that this approach is subjective, but it does provide a reasonable method of evaluating several different systems against several different requirements. The results of this approach are shown in Table 5-1.

We then multiplied the weighting factors by the rankings to obtain the total scores by system, as shown in Table 5-2. As a measure of confidence in this approach, we weighted the candidate systems against the requirements using several different weighting schemes. In each method we used, the relative outcomes were approximately the same as the results displayed in the table.

5.2 NEAR TERM

The near term represents a distinctly unique problem with perhaps an oversimplified solution. An examination of the choices available now for the near term provides limited choices:

- Continue to use the AN/TPN-18 (Rank: 6th out of 7 -- see weighted total scores at bottom of Table 5-2).
- Procure and use an MRAALS system (Rank: 4th out of 7) or MADGE system (Rank: 7th out of 7).
- Do not fly missions in IMC forward of the division rear.

MRAALS is not a viable possibility, because the avionics will not be available until 1989. MADGE is available; however, it would require a new procurement, would not be interoperable with other services or with civil requirements, and would necessitate installation of multiple LRUs in each aircraft. Therefore, the reasonable choice is to proceed with using the AN/TPN-18. It must be clearly understood, however, that this radar does not meet the requirements of an APLS and is only an interim solution for operating in the division rear. The mobility and exploitability of this radar preclude using it in the brigade, where assistance is most needed. In the near term, brigade landing emergencies might be assisted by using Non-Directional Beacons (NDB) as suggested in TB 380-6-6, Electronic Security (ELSEC) for Aviation Battlefield Survivability, 12 May 1980. Both the AN/TPN-18 and the NDBs are strictly interim approaches to the problem.

5.3 MID TERM

As shown in Table 5-2, the GPS scores highest and thus appears to be the best candidate for the Army, but several points must be considered. First, further testing is needed to verify that the GPS can be used to penetrate IMC down to levels typical of Army forward area helicopter flight. Second, this approach assumes Army acceptance of an on-board landing solution. Third, the GPS differential transmitter, if required, must be able to serve a large area, at a reasonable cost, and not require a time-consuming survey. Since the Army is already planning to install

TABLE 5-1

SYSTEM RANKS VERSUS WEIGHTED REQUIREMENTS

Requirement	Weighting Factor	System Rank						
		AN/TPN-18	TLS	TMLS	MRAALS	MADGE	BLS	GPS
Range	1	7	4	2	4	7	1	7
Elevation	2	7	1	2	5	4	3	7
Azimuth	1	5	5	2	7	1	3	7
Maximum Number of Aircraft Handled	1	4	7	7	4	4	4	7
Recovery Intervals	1	7	6	6	6	6	6	6
Separation	1	7	6	6	6	6	6	6
Alignment	1	1	7	7	7	7	7	2
Susceptibility	3	1	5	6	2	4	3	7
Deployability	1	1	6	6	6	3	7	2
Interoperability	3	7	4	7	4	2	1	7
Training	1	7	5	5	3	2	2	6
Personnel Impact	1	1	5	4	3	3	6	7
R&M	1	1	3	7	5	4	6	2
Ancillary Equipment	1	3	2	7	4	7	7	
Commonality	1	7	7	7	3	1	2	7
Useful Life	1	1	7	7	7	7	7	7
Affordability								
Risk	1	7	2	4	7	7	1	4
Cost								
Ground System	2	1	5	3	4	2	6	7
Ground and Avionics Systems	1	6	4	5	3	1	7	2
Survivability	1	1	5	6	2	4	3	7

GPS on the helicopters previously listed in Table 4-2, testing to resolve these points further should be initiated. AVRADA has planned some of these tests and should be involved at the outset. The GPS appears to be the only system capable of supporting all landing requirements for the severe constraints of the forward battlefield environment.

TABLE 5-2

SYSTEM WEIGHTED TOTAL SCORES

Requirement	Weighting Factor	System Score						
		AN/TPN-18	TLS	TMLS	MRAALS	MADGE	BLS	GPS
Range	1	7	4	2	4	7	1	7
Elevation	2	14	2	4	10	8	6	14
Azimuth	1	5	5	2	7	1	3	7
Maximum Number of Aircraft Handled	1	4	7	7	7	4	4	7
Recovery Intervals	1	7	6	6	6	6	6	6
Separation	1	7	6	6	6	6	6	6
Alignment	1	1	7	7	7	7	7	2
Susceptibility	3	3	15	18	6	12	9	21
Deployability	1	1	6	6	6	3	7	2
Interoperability	3	21	12	21	12	6	3	21
Training	1	7	5	5	3	2	2	6
Personnel Impact	1	1	5	4	3	3	6	7
R&M	1	1	3	7	5	4	6	2
Ancillary Equipment	1	1	3	2	7	4	7	7
Commonality	1	7	7	7	3	1	2	7
Useful Life	1	1	7	7	7	7	7	7
Affordability								
Risk	1	7	2	4	7	7	1	4
Cost								
Ground System	2	2	10	6	8	4	12	14
Ground and Avionics Systems	1	6	4	5	3	1	7	2
Survivability	1	1	5	6	2	4	3	7
Totals		104	121	132	119	97	105	156
Overall Rank Based on Totals		6	3	2	4	7	5	1

The next most suitable system is the TMLS. Since it is a glide-slope-oriented system, using it to land in small clearings could be a problem, since a step-down approach would be preferable (see Appendix E). Furthermore, a helicopter flying at 100 feet or less would likely be below the

TMLS's lower elevation angle at approach distances greater than approximately 2 kilometers, rendering the TMLS's vertical guidance unusable. This elevation problem should be addressed, with Army representatives at the Joint Project Office for TMLS, for early consideration to determine whether the TMLS lower elevation angle can be lowered to 0°. Early resolution is particularly important since the Army is planning to install TMLS on the platforms shown in Table 4-2 and is ready to complete the Required Operational Capability for an Army version of TMLS.

5.4 LONG TERM

RAC appears to be a potential long-term candidate. An RAC system is now being used as a guidance system, and R&D funds will be required to investigate the feasibility of using the RAC as a landing system. It should be possible to resolve the landing problem in the brigade area without resorting to a ground solution; i.e., the pilot should be able to fly in all categories of weather and land where desired without resorting to an external ground-based aid. The RAC system represents a possible solution for the long term.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The major conclusions of this evaluation of landing system alternatives are as follows:

- There is disagreement between doctrine and operational practice regarding the need to land helicopters in both the division and brigade areas in IMC.

- The Army requires a precision landing system in the area forward of the division rear in addition to the TMLS programmed for the division landing sites.

- The near-term system of choice is continued use of the AN/TPN-18 in the division rear and nondirectional beacons (NDBs) as proposed in TB 380-6-6. This solution does not meet the APLS requirements, nor does it allow the planned flying of missions and landing in IMC conditions in the forward area.

- The mid-term solution is either GPS or TMLS. GPS appears to be the only system capable of supporting an APLS requirement, if an on-board landing solution is acceptable to the Army. TMLS is the second best alternative, but some redefinition of specifications would be necessary. As noted below, furth~r testing or specification redefinition is required to substantiate this conclusion.

- The long-term solution appears to be undefined. The RAC concept offers promise for a long-term passive landing system when coupled with some means for a precise glide slope or descent path.

6.2 RECOMMENDATIONS

The following actions are recommended:

- Use of the AN/TPN-18 should be continued.

- The preliminary requirements presented in this report should be carefully reviewed by and discussed with TRADOC, AVRADA, and other interested Army user organizations to ensure the validity and proper statement of APLS needs. Industry should also be consulted to ensure current availability of technology and equipment and to derive a comprehensive statement of production, deployment, and cost risks. The Army DROC TMLS should be revised to include the quantities required for the forward area.

- The concept of a tactical automated Air Traffic Management System should be investigated and developed. Separation procedures in the forward area must be addressed.

- The use of GPS as a precision landing system should be investigated, and AVRADA should test the ability of GPS to land under IMC category II conditions. This testing should also determine the necessity for using differential or pseudolite ground stations as well as the susceptibility and deployability of such ground stations, if required.

- The possibility of lowering the TMLS lower elevation angle should be referred to Army representatives at the TMLS Project office for resolution.

- The possibility of using a RAC system in a helicopter should be investigated. The range should be compatible with the altitudes at which the helicopters will be flying in the forward area.

APPENDIX A

ORGANIZATION AND OPERATIONAL (O&O) PLAN
FOR
EMPLOYMENT OF THE OH-58D ARMY HELICOPTER
IMPROVEMENT PROGRAM (AHIP) HELICOPTER

This appendix provides a copy of the O&O plan on AHIP to illustrate the flight and mission requirements and, in particular, the flight profiles. Also, note (pages A-44 and A-53) the large number of required mission hours per year.

OPERATIONAL AND ORGANIZATIONAL (O&O) PLAN

FOR

EMPLOYMENT OF THE OH-58D

ARMY HELICOPTER IMPROVEMENT PROGRAM (AHIP) HELICOPTER

UNITED STATES ARMY AVIATION CENTER

FORT RUCKER, ALABAMA 36362

MARCH 1985

OPERATIONAL AND ORGANIZATIONAL (O&O) PLAN
FOR EMPLOYMENT OF THE OH-58D
ARMY HELICOPTER IMPROVEMENT PROGRAM (AHIP) HELICOPTER

1. PURPOSE.

a. The deficiencies of the current scout aircraft, the OH-58A/C, are described in the Army Aviation Mission Area Analysis, January 1982 (chapter 6, pages 63-64).

b. US land forces need tactical surveillance, reconnaissance, and target acquisition/hand over systems capable of immediate response to the commander's needs. The scout helicopter must be capable of performing in day/night or adverse weather. The scout is required to participate as a member of the combined arms team and to be employed with joint attack teams to defeat enemy armored weapons, hardpoint targets, and troop concentrations. It should provide highly mobile target acquisition/designation for precision-guided munitions, employment of indirect fire support, area security for the attack aircraft, reconnaissance, and coordination of close air support. Its sensors and designators should provide sufficient standoff range to detect and acquire targets prior to being acquired and engaged by enemy close combat systems. It must possess adequate performance and agility for immediate response to fluid battlefield conditions. The scout helicopter should provide increased survivability for itself and the scout/attack team through low detectability, inherent mobility, and self-protection against chance encounters with enemy aircraft. The aircraft and crew should be equipped to survive known threats including nuclear, biological, and chemical and lasers while successfully performing the mission. It should provide the air battle captain (ABC) with command and control capability over the scout/attack team.

c. A need exists to navigate accurately in a nap-of-the-earth (NOE) environment in order to reach combat areas where scout functions are needed. The scout pilot must be able to acquire and identify a target with minimum exposure of the aircraft. He must be able to identify the target coordinates, which requires that he be able to accurately measure the distance from the aircraft to the target. He must be able to communicate the target information to attack aircraft or artillery units to the rear or pass intelligence information while remaining in an NOE environment. The aircraft should have sufficient power and handling qualities to allow it to safely perform its mission.

2. THREAT/DEFICIENCY.

a. The threat to be defeated is enemy armored units and materiel targets that must be destroyed by attack aircraft, artillery, or other fire support systems. The mission assigned to the scout aircraft will expose it during day, night, and marginal visibility conditions to the entire spectrum of threat formations and weapons. This threat is highly mobile and is comprised primarily of air defense weapons such as radar, infrared, and optically guided

surface-to-air missiles and direct fire antiaircraft weapons.

b. The Light Observation Helicopter now serves as the scout helicopter; however, it does not possess the mission equipment necessary to perform the scout functions of day/night/reduced visibility target acquisition and laser designation for air cavalry, attack helicopter, and field artillery units or a self-defense capability against the enemy helicopter threat. It does not possess the performance characteristics needed to operate efficiently in the NOE environment.

3. OPERATIONAL PLAN.

a. There are three general types of operation that will employ the scout helicopter: antiarmor, air cavalry, and indirect fire support. The scout aircraft will be used primarily for reconnaissance, security, observation, target acquisition/designation and hand over missions. These missions will be conducted at maximum feasible stand-off ranges and at NOE flight altitudes for increased survivability. The scout aircraft will be capable of communicating with all US ground units in the corps area, other Army aircraft, and US Air Force, Navy, and Marine Corps aircraft. The scout aircraft will need to operate in all the environmental and climatic categories where US forces would be deployed. It will be operating in day, night, and marginal visibility conditions.

b. Attack helicopter antiarmor operations are intended to destroy armored enemy vehicles in day, night, or marginal visibility conditions. The main effort of the scout is oriented toward finding tanks and providing maximum protection for the attack helicopters. Thus, the scout aircraft will enhance the survivability of the attack aircraft and will extend the coverage of the battlefield, which is especially important in the NOE flight environment. The attack helicopter company will be composed of four scout and six attack aircraft. The scout/attack team will consist of three scout and five attack aircraft. During the actual engagement, the scout aircraft will locate, acquire, and designate targets for the attack aircraft, thereby reducing the attack aircraft's exposure time. In some cases, when remote target designation is used, the attack aircraft can launch its missiles while remaining masked. The scout aircraft will also possess the ability to transmit digital target data for target hand over to the attack aircraft if the attack aircraft is equipped with the airborne target hand over system (ATHS). The ABC will occupy one of the scout aircraft and will coordinate the employment of the scout/attack team. He will also determine the method of deployment for the scout and attack aircraft, the prioritization of targets, and the preferred method of engagement. In addition, he will coordinate with the ground commander, coordinate indirect fire, and assist the forward air controller. While in the battle positions, the attack aircraft are oriented to the primary mission of attacking ground targets. Based upon the air threat and the friendly air defense situation, the ABC can assign the scouts the primary mission of acquiring and designating targets for the attack helicopters and a secondary mission of providing protection against the air threat with the onboard air-to-air Stinger (ATAS); or he can assign counterair against the air threat to provide a specially tasked air defense capability as the primary

mission. If he assigns protection against the air threat as the primary mission, scouts normally occupy positions that cover enemy air avenues of approach into the combat area that are not covered by friendly ground air defense. They also choose positions which maximize the ATAS capabilities. If all avenues of approach are covered by ground air defense, the scouts thicken the most likely air avenues by providing surveillance for ground or air threats.

c. Just as in ground cavalry operations, air cavalry units perform reconnaissance, security, and economy-of-force operations; but, unlike attack helicopter operations, the focus is on the scout helicopters with the attack helicopters providing protection for the scout. The scout helicopters' primary function is to provide information to the supported commander. The air cavalry troop will be composed of six scout and four attack aircraft. The air cavalry team normally consists of five scout and three attack aircraft. The most frequent missions given to air cavalry units are reconnaissance and screening. Normally, the scout helicopters operate in pairs and, depending on the enemy, may or may not be accompanied by an attack helicopter. Continuous operations are important to the air cavalry troop. Consequently, the scout helicopter force will frequently be employed in thirds. Augmented with the attack helicopter, the scouts provide a credible antiarmor capability and, although not their primary function, can detain a sizeable tank force.

d. During rear battle operations, scout helicopters operate in an offensive air-to-air role with onboard air-to-air weapons. Scout and attack helicopters may be diverted from existing missions or assigned the rear battle mission as a primary. Army aviation is notified of an incoming air assault or air raid through the existing command and control network. The ABC is provided with the suspected target and the suspected flight route. The ABC selects where he desires to engage the threat air elements, moves to that point of intercept, places his attack assets (OH-58D's) in hide positions, gains early detection, and engages the threat. When assigned to rear battle missions, the ABC deploys his scout aircraft along likely air avenues of approach. When the enemy aircraft are detected, the scout determines the general flight route and passes this information to the ABC. The ABC again selects the kill zone which he desires to use, moves his attack assets to hide positions around that kill zone, adjusts with updated information, and attacks the threat air formation by surprise.

e. During combat assaults into hostile territory, scout aircraft with onboard ATAS will provide local counterair protection. Short-range attacks, using ATAS, are accomplished by the escort aircraft to destroy or neutralize the threat aircraft while the combat assault continues. Escort aircraft use air-to-air combat maneuvers to engage and neutralize the threat air attack.

f. Each division has scout helicopters dedicated to providing artillery (observers) with the capability to rapidly maneuver to critical areas to provide indirect fire support functions. In addition to being able to employ conventional artillery, the OH-58D helicopter will provide the capability to laser designate for Copperhead and all tri-service laser munitions against

tank and point targets. Other artillery missions performed by the OH-58D will include target acquisition and hand over, reconnaissance, and intelligence reporting. The ATHS will allow transmission of digital target information to the tactical fire system.

g. The operational mode summary/mission profile is attached as annex A.

4. ORGANIZATIONAL PLAN. The units to be equipped with the OH-58D are attack helicopters, air cavalry, and field artillery aerial observer support elements. All units receiving the AH-64 will also receive the OH-58D as a one-for-one replacement for OH-58A/C aircraft now employed in the scout role. All OH-58A/C aircraft being used for the field artillery aerial observer (FAAO) mission will also be replaced by the OH-58D on a one-for-one basis. Attack helicopter and cavalry units not designated to receive the AH-64 may not receive the OH-58D as replacement for the OH-58A/C. Based on the current organizational structure for Army aviation, the OH-58D will replace the existing OH-58A/C scouts in the following units:

a. Each attack battalion in heavy, airborne, and air assault divisions; the heavy corps; and the contingency corps will receive 13 OH-58D aircraft.

b. Each cavalry troop in the air assault division will receive six OH-58D's as interim aircraft until the fielding of the Family of Light Helicopters.

c. The number of OH-58D aircraft designated to perform the FAAO mission will vary depending on the type unit being supported. The use of OH-58D's in the FAAO role, by unit type, is as follows:

(1) A heavy division will have six OH-58D aircraft organic to the combat aviation company (general support) to perform the FAAO mission.

(2) The High Technology Light Division (9th Infantry Division) will have 10 OH-58D aircraft organic to the general support aviation company to perform the FAAO mission.

(3) Each corps will have 15 OH-58D aircraft organic to the artillery aviation company in the corps aviation brigade.

5. PERSONNEL IMPACT. The anticipated OH-58D crew will consist of one pilot and one enlisted aerial observer. For FAAO missions, a field artillery officer will function as an aerial observer. No new manning requirements will be created. However, due to the introduction of new systems specific to the OH-58D and significant differences between the OH-58C and the OH-58D, two new military occupational specialties (MOS) will be created for the OH-58D repairman (MOS 67S) and technical inspector (MOS 66S). The manpower authorization criteria for the number of 67S's per OH-58D is not expected to change from the number of 67Vs per OH-58C.

6. TRAINING IMPACT.

a. New Equipment Training. The OH-58D will require operation and maintenance NET for instructor and key personnel during the fielding phase to the first unit equipped. As part of the new equipment training, factory training will be required to provide a complete transfer of knowledge from the contractor to the government. These courses will be time-phased to meet the specific needs of the Army in the development of the OH-58D. Instructor and key personnel training (IKPT) courses will be designed to provide complete hardware training. IKPT courses will result from contractor courses developed under the system approach to training (SAT) concept. These courses will be refined and updated as a result of developmental testing/operational testing training evaluation and Logistic Support Analysis Report (LSAR) data. IKPT courses are for those personnel who shall establish the resident training base and serve on the new equipment training team (NETT). IKPT courses provided by the contractor will be reviewed and approved by the proponent school and the US Army Training and Doctrine Command (TRADOC) prior to the beginning of IKPT. Additional new equipment training will be conducted by the new material introduction briefing team (NMIBT) and the NETT. The NMIBT will brief all gaining unit major commanders on the OH-58D prior to delivery of the system. The briefing will consist of system capabilities and limitations, support requirements, and procedures peculiar to the equipment. The NETT will deploy 17 to 24 instructors (tailored to the unit receiving support) to teach up to 8 weeks of instruction at aviation unit maintenance (AVUM) and aviation intermediate maintenance (AVIM) levels for both crew and maintenance personnel qualification. Due to the significantly increased capabilities of the OH-58D and the lengthy training courses, establishment of an institutional training base at the earliest possible date becomes imperative. The present training strategy includes only one NETT effort for the initial operational capability unit, followed by institutionally trained personnel to a single unit fielding base.

b. Institutional Training. Institutional training will be conducted for operator and maintenance personnel and will be designed for support of production-version OH-58Ds. This training will be based in part on the training courses provided during full-scale engineering development and on courses conducted at IKPT. These courses may require restructuring to support resident training requirements. Other products provided for by contract that will assist in establishing resident courses include manuals in the New Look format, task and skill analysis, training device study, LSAR data, and Army-conducted cost and training effectiveness analysis data. Appropriate existing officer and noncommissioned officer courses will be modified as necessary to incorporate new data, doctrine, and concepts of employment, operation, and maintenance. Doctrinal publications affected by the fielding of the OH-58D will be changed as required. These changes will be implemented at the course start date. Tactical/combat skill training will be developed at the US Army Aviation Center and implemented during the aviator and observer qualification courses. Combat skill training for the crewmembers is considered an essential portion of a crewmember's qualifications.

c. Unit Training. Unit training will supplement institutional training and will enable personnel to meet the operational requirement with the OH-58D. The sustainment of individual skill training is a part of unit training. This training will be supported by the proponent centers and schools with the necessary training materials. Individual proficiency will be measured by the skill qualification test and aircrew training manual. Collective training will be accomplished at the unit level and will be evaluated through the appropriate Army training and evaluation program. Combined arms team operations incorporating the OH-58D against a realistic threat array will be the primary collective training objective. Doctrinal and tactical training will be developed by TRADOC and will be provided as subject training to all levels of command that are expected to be involved in the employment decisions of the OH-58D. Instructions will address capabilities and limitations, system interface with existing systems, and operational concepts of employment.

d. Training Subsystem. The training subsystem developed for the OH-58D will be based on performance requirements obtained through analysis of data generated in accordance with DARCOM Pam 750-16. The training products developed as part of the training subsystem will be designed according to the SAT (TRADOC Reg 350-7).

e. Training Devices/Simulators. The following training devices/simulators are being developed: cockpit procedures trainer, classroom systems trainer, composite maintenance trainer, engine maintenance trainer, composite electrical trainer, avionics electrical trainer, and test support system. Certain aircraft components will also be procured as training aids. Two training devices have been identified for future development--a multifunction display recorder and a target recognition identification trainer for the thermal imaging system.

7. LOGISTICS IMPACT.

a. The generalized maintenance concept for the OH-58D is in consonance with the provisions anticipated for Army aircraft maintenance in the year 1990 and beyond. Both the maintenance system and the reliability, availability, and maintainability characteristics of the aircraft will be designed to support the increased operational requirements of Army 21.

b. The aviation maintenance system supporting the OH-58D will remain essentially a three-level system designed to limit piece/part repair at the lower levels of maintenance. In order to optimize the aircraft availability, the concept of progressive phased maintenance will be utilized for all scheduled maintenance. Modules and line-replaceable units (LRU) will be discarded or evacuated as appropriate. Maximum use will be made of onboard troubleshooting and built-in tests to provide real-time condition and trend recording. The Test Support System (TSS) will be utilized to diagnose and designate LRUs for repair or evacuation. The TSS will eventually be replaced by the Intermediate Forward Test Equipment.

c. The OH-58D will minimize time-change components and use on-condition maintenance to the maximum extent possible. Maintenance actions should be accomplished with those common tools and test, measurement, and diagnostic equipment applicable to 1990 and beyond. Augmentation by special tools and test equipment should be minimal. The OH-58D will incorporate effective use of test and diagnostic equipment to facilitate rapid accomplishment of required maintenance and return to operationally ready status.

d. AVUM is organic to and has the same mobility requirement as the parent unit and is responsible for preventive maintenance and limited corrective maintenance to the OH-58D. Each AVUM organization will have a battle damage assessment capability and a tailored recovery kit which will permit standard rigging of its aircraft. AVUM personnel will be capable of assessing damage, effecting quick-fix repair of battle damage, and rigging aircraft for recovery.

e. AVIM is the sole maintenance level above AVUM. The AVIM organizations will perform repairs at their field locations and on site. They will operate a supply activity for modular replacement units, combat-based spares, and float end items. Maintenance support teams will provide quick-response, supplementary support to AVUM by accomplishing on-site repairs, delivering float items to replace combat losses, providing backup combat battle damage assessment, quick-fix, cannibalization, controlled exchange, and recovery.

f. The supply system will utilize state-of-the-art technology to provide rapid supply support, thereby minimizing the pipeline. AVIM units will stock modular replacement units, combat-based spares, direct exchange items, demand supported items, and float end items.

g. Depot-level organizations will be established as required. The depot will accomplish overhaul and rebuild of components and will return the maximum number of items to the supply system. Portions of echelons above corps depot maintenance may be performed by contractors. Contractor maintenance, where necessary, will expand the manpower base for high technology skills and augment organic maintenance manpower, facilities, and equipment.

8. FUNDING IMPLICATIONS. The following program costs are in escalated current year dollars:

a. Total RDTE Cost. $235.8M.

b. Total Procurement Cost. $2,432.3M.

c. Total Program Acquisition Unit Cost (Based on 583 Aircraft). $4.58M.

d. Total Life Cycle Cost. $7,153.6M.

ANNEX A

OPERATIONAL MODE SUMMARY/MISSION PROFILES (OMS/MP)
FOR THE OH-58D

1. PURPOSE. This annex provides a set of probable operational mission profiles for the OH-58D scout and a statistical distribution of frequency of events.

2. PROFILES. The profiles are not intended to include all possible missions but to provide a broad representative base for analysis. All profiles are given in both the European and Middle East settings.

3. OPERATIONAL MODE SUMMARY. Profiles are followed by a summary of types of missions and annual flight requirements.

MISSION PROFILE

OH-58D SCOUT

ANTIARMOR-EUROPE

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	+
Tank main gun	+
Small caliber gun	+
Small arms	0
Ground-launched ATGM	+
Close air support (high performance/helicopter)	0/+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	+
Dust	-
Rains	+
Sleet/Snow/ice	+
Built-up areas	+

c. Terrain Elevation (average in feet).

Peaks - 1,699

Valleys - 748

Overall - 1,223

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	32	44	50	34
Mean high temperature (°F)	41	62	69	45
Precipitation (inches per season)	5.7	6.9	11.6	7.1
Fog (days per season)	33	11	4	30
Duration of fog (hours per day)	6.0	3.6	3.2	5.0
Visibility $\leq$ 3,000m (percent)	22	9	9	19
Ceiling $\leq$ 1,500 ft (percent)	24	11	8	20
Relative humidity (percent)	80-90	70-80	70-80	80-90

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (helicopters, personnel)	100

4. MISSION DESCRIPTION.

a. Type: Attack mission in antiarmor role. Scouts coordinate and lead the mission. They gather target information, designate targets, select battle positions for attack helicopters, provide security, and coordinate with ground commanders. When necessary, they adjust indirect fire and close air support.

b. Distance: Radius of action of up to 100 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: N/A.

d. Frequency: As required.

e. Urgency: Combat.

f. Situation: Europe V.

g. Flight profile: See attached flight profile.

FLIGHT PROFILE

ANTIARMOR-EUROPE

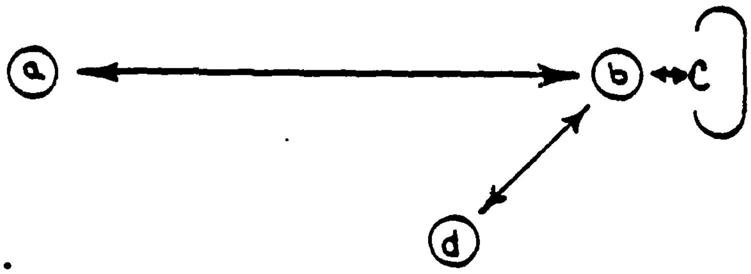
1. Graphic.

a. Assembly area (AA).

b. Holding area.

c. Battle position.

d. FARP.



2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	100	148	Contour
b-c	2	56	NOE
On station	Loiter 20 min	Variable	HOGE/NOE
c-b	2	56	NOE
b-d	21	148	Contour
d-b	21	148	Contour
b-c	2	56	NOE
On station	Loiter 20 min	Variable	HOGE/NOE
c-b	2	56	NOE
b-a	100	148	Contour

MISSION PROFILE

OH-58D SCOUT

ANTIARMOR-MIDEAST

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	+
Tank main gun	+
Small caliber gun	+
Small arms	0
Ground-launched ATGM	+
Close air support (high performance/helicopter)	0/+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	0
Dust	+
Rains	-
Sleet/snow/ice	-
Built-up areas	-

c. Terrain elevation (average in feet).

Peaks - 8,494

Valleys - 6,094

Overall - 7,294

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	27	49	72	53
Mean high temperature (°F)	45	71	99	76
Precipitation (inches per season)	5.0	2.0	.3	2.5
Relative humidity (percent)	55	35	26	60
Ceiling/visibility $\leq$ 1,500 ft/3 mi (percent)	3	1	2	3

Pressure altitude presents a problem in hot weather. Average pressure altitude during the summer is 7,485 feet.

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (helicopters, personnel)	100

4. MISSION DESCRIPTION.

a. Type: Attack mission in antiarmor role. Scouts coordinate and lead the mission. They gather target information, designate targets, select battle positions for attack helicopters, and provide security. They adjust indirect fire and close air support when necessary.

b. Distance: Up to 300 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: N/A.

d. Frequency: As required.

e. Urgency: Combat.

f. Situation: Mideast III.

g. Flight profile: See attached flight profile.

FLIGHT PROFILE

ANTIARMOR-MIDEAST

1. Graphic.

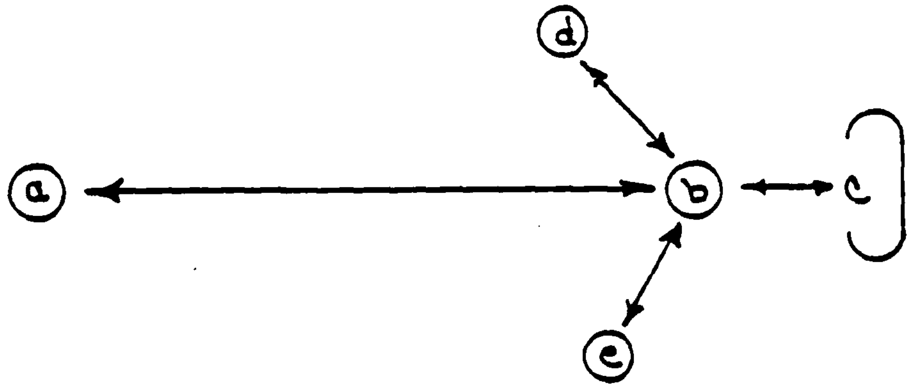
a. Assembly area.

b. Holding area.

c. Battle position.

d. FARP.

e. FARP.



2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	150	148	Contour
b-c	2	56	NOE
On station	Loiter 20 min	Variable	HOGE/NOE
c-b	2	56	NOE
b-d	25	148	Contour
d-b	25	148	Contour
b-c	2	56	NOE
On station	Loiter 20 min	Variable	HOGE/NOE
c-b	2	56	NOE
b-e	25	148	Contour
e-b	25	148	Contour
b-c	2	56	NOE
On station	Loiter 20 min	Variable	HOGE/NOE
c-b	2	56	NOE
b-a	150	148	Contour

MISSION PROFILE

OH-58D SCOUT

RECONNAISSANCE-EUROPE

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	0
Air defense artillery (missile)	0
Artillery	0
Tank main gun	0
Small caliber gun	0
Small arms	+
Ground-launched ATGM	0
Close air support (high performance/helicopter)	0/+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	+
Dust	-
Rains	+
Sleet/Snow/ice	+
Built-up areas	+

c. Terrain Elevation (average in feet).

Peaks - 1,699

Valleys - 748

Overall - 1,223

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	32	44	50	34
Mean high temperature (°F)	41	62	69	45
Precipitation (inches per season)	5.7	6.9	11.6	7.1
Fog (days per season)	33	11	4	30
Duration of fog (hours per day)	6.0	3.6	3.2	5.0
Visibility ≤ 3,000m (percent)	22	9	9	19
Ceiling ≤ 1,500 ft (percent)	24	11	8	20
Relative humidity (percent)	80-90	70-80	70-80	80-90

2. MISSION (percent of time).

Offense	Defense	Total
30	70	100

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (personnel, helicopters)	100

4. MISSION DESCRIPTION.

a. Type: Area/route reconnaissance of a zone not thought to contain enemy forces.

b. Distance: In excess of 150 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: N/A.

d. Frequency: As required.

e. Urgency: Combat.

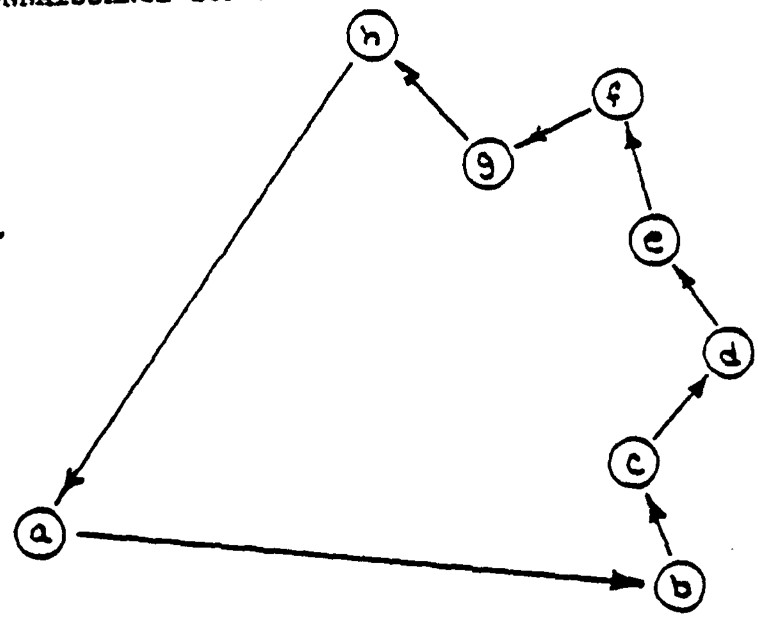
f. Situation: Europe V.

g. Remarks: A scout/attack team is conducting a reconnaissance of an area which a friendly force will occupy. The greatest threat is a chance encounter with enemy air or ground reconnaissance elements.

h. Flight profile: See attached flight profile.

FLIGHT PROFILE

RECONNAISSANCE-EUROPE



1. Graphic.

   a. Base.

   b. Air contact point (ACP).

   c. ACP.

   d. ACP.

   e. ACP.

   f. ACP.

   g. ACP.

   h. ACP.

2. Description of profile legs.

	Distance (km)	Speed	Flight Mode
a-b	40	Vbr	Contour
b-c	20	Vbe	NOE/contour
c-d	25	Vbe	NOE/contour
d-e	15	Vbe	NOE/contour
e-f	20	Vbe	NOE/contour
f-g	15	Vbe	NOE/contour
g-h	25	Vbe	NOE/contour
h-a	20	Vbr	Contour

(Vbr - velocity best range)
(Vbe - velocity best endurance)

MISSION PROFILE

OH-58D SCOUT

RECONNAISSANCE-MIDEAST

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	0
Air defense artillery (missile)	0
Artillery	0
Tank main gun	0
Small caliber gun	0
Small arms	+
Ground-launched ATGM	0
Close air support (high performance/helicopter)	0/+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	0
Dust	+
Rains	-
Sleet/snow/ice	-
Built-up areas	-

c. Terrain Elevation (average in feet).

Peaks - 8,494

Valleys - 6,094

Overall - 7,294

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	27	49	72	53
Mean high temperature (°F)	45	71	99	76
Precipitation (inches per season)	5.0	2.0	.3	2.5
Relative humidity (percent)	55	35	26	60
Ceiling/visibility $\leq$ 1,500 ft/3 mi (percent)	3	1	2	3

Pressure altitude presents a problem in hot weather. Average pressure altitude during the summer is 7,485 feet.

2. MISSION (percent of time).

Offense	Defense	Total
45	55	100

3. TYPE OF TARGET. Percent of total targets expected to be engaged by the system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (personnel, helicopters)	100

4. MISSION DESCRIPTION.

a. Type: Route/area reconnaissance within a zone not thought to be occupied by enemy forces.

b. Distance: In excess of 200 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers:

d. Frequency: As required.

e. Urgency: Combat.

f. Situation: Mideast III.

g. Remarks: A scout/attack team is conducting a reconnaissance of an area that a friendly force will occupy. The greatest threat to the team is a chance encounter with enemy air or ground reconnaissance elements.

h. Flight profile: See attached flight profile.

FLIGHT PROFILE

RECONNAISSANCE—MIDEAST

1. Graphic.

   a. Cavalry troop.

   b. ACP 2.

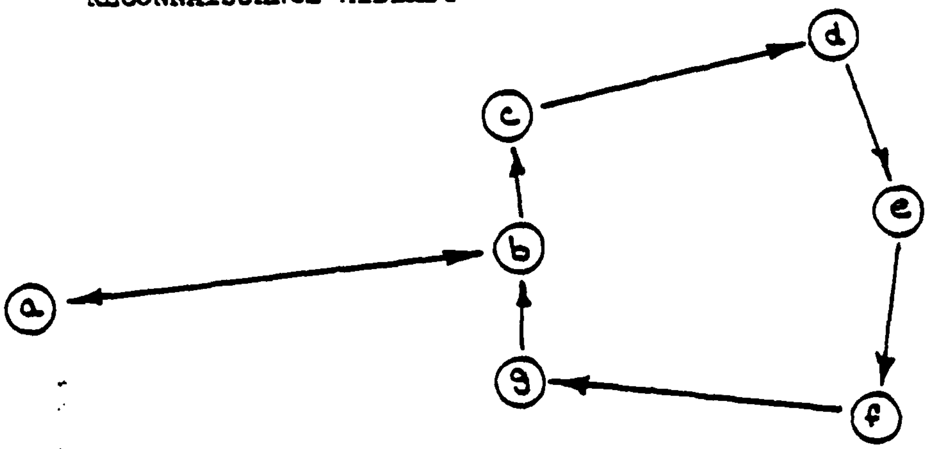
   c. ACP 3.

   d. ACP 4.

   e. ACP 5.

   f. ACP 6.

   g. ACP 7.



2. Description of profile legs.

	Distance (km)	Speed	Flight Mode
a–b	60	Vbr	Contour
b–c	10	Vbe	NOE/contour
c–d	30	Vbe	NOE/contour
d–e	20	Vbe	NOE/contour
e–f	20	Vbe	NOE/contour
f–g	30	Vbe	NOE/contour
g–b	10	Vbe	NOE/contour
b–a	60	Vbr	Contour

(Vbr - velocity best range)
(Vbe - velocity best endurance)

MISSION PROFILE

OH-58D SCOUT

ANTIPERSONNEL/MATERIEL-EUROPE

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	-
Tank main gun	-
Small caliber gun	-
Small arms	+
Ground-launched ATGM	-
Close air support (high performance/helicopter)	+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	+
Dust	-
Rains	+
Sleet/Snow/ice	+
Built-up areas	+

c. Terrain Elevation (average in feet).

Peaks - 1,699

Valleys - 748

Overall - 1,223

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	32	44	50	34
Mean high temperature (°F)	41	62	69	45
Precipitation (inches per season)	5.7	6.9	11.6	7.1
Fog (days per season)	33	11	4	30
Duration of fog (hours per (day)	6.0	3.6	3.2	5.0
Visibility $\leq$ 3,000m (percent)	22	9	9	19
Ceiling $\leq$ 1,500 ft (percent)	24	11	8	20
Relative humidity (percent)	80-90	70-80	70-80	80-90

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (helicopters, personnel)	100

4. MISSION DESCRIPTION.

a. Type: Attack mission forward of friendly lines against a weakly defended soft target. Scouts coordinate and lead the mission.

b. Distance: Radius of action of up to 100 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: N/A.

d. Frequency: As required.

e. Urgency: Combat.

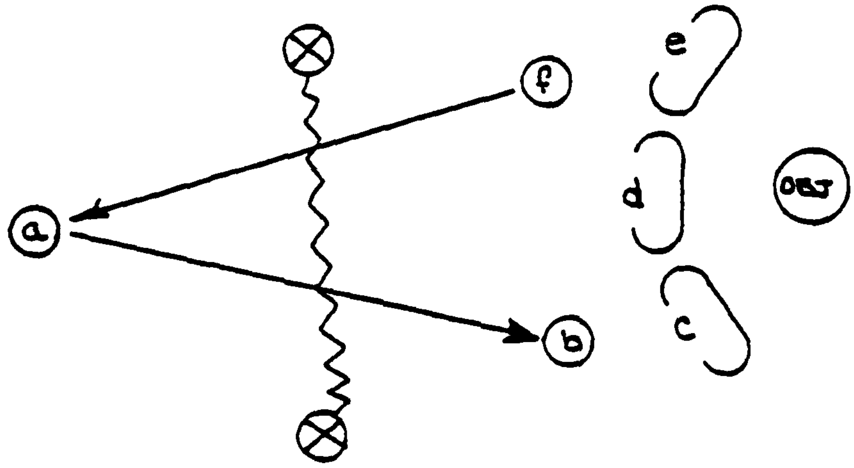
f. Situation: Europe V.

g. Flight profile: See attached flight profile.

FLIGHT PROFILE

ANTIPERSONNEL/MATERIEL-EUROPE

1. Graphic.



   a. Assembly area.

   b. Holding area.

   c. Battle position (BP).

   d. BP.

   e. BP.

   f. Transition point.

2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	50	148	Contour
b-BPs	±2	56	NOE
On station, vicinity BPs	Loiter 15 min	Variable	HOGE/NOE
BPs-f	±2	56	NOE
f-a	50	148	Contour

MISSION PROFILE

OH-58D SCOUT

ANTIPERSONNEL/MATERIEL-MIDEAST

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	-
Tank main gun	-
Small caliber gun	-
Small arms	+
Ground-launched ATGM	-
Close air support (high performance/helicopter)	+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	0
Dust	+
Rains	-
Sleet/snow/ice	-
Built-up areas	-

c. Terrain elevation (average in feet).

Peaks - 8,494

Valleys - 6,094

Overall - 7,294

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	27	49	72	53
Mean high temperature (°F)	45	71	99	76
Precipitation (inches per season)	5.0	2.0	.3	2.5
Relative humidity (percent)	55	35	26	60
Ceiling/visibility, ≤ 1,500 ft/3 mi (percent)	3	1	2	3

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (helicopters, personnel)	100

4. MISSION DESCRIPTION.

a. Type: Attack mission forward of friendly lines against a weakly defended soft target. Scouts lead and coordinate the mission.

b. Distance: Radius of action up to 100 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: N/A.

d. Frequency: As required.

e. Urgency: Combat.

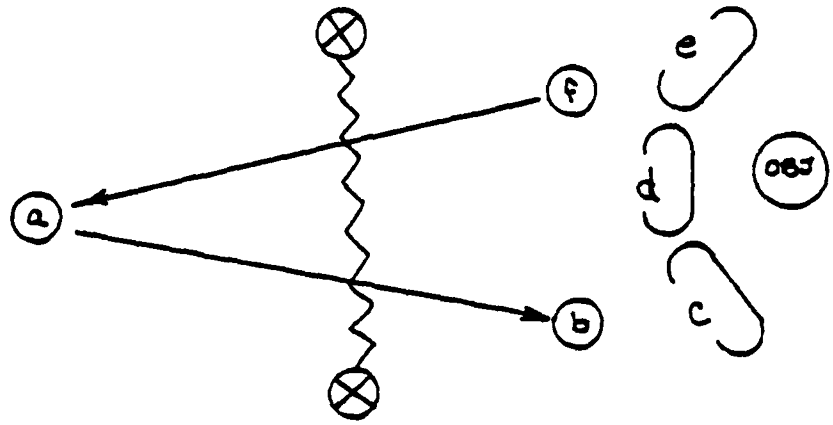
f. Situation: Mideast III.

g. Flight profile: See attached flight profile.

FLIGHT PROFILE

ANTIPERSONNEL/MATERIEL-MIDEAST

1. Graphic.



a. Assembly area.

b. Holding area.

c. Battle position (BP).

d. BP.

e. BP.

f. Transition point.

2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	100	148	Contour
b-BPs	±2	56	NOE
On station, vicinity BPs	Loiter 15 min	Variable	HOGE/NOE
BPs-f	±2	56	NOE
f-a	100	148	Contour

MISSION PROFILE

OH-58D SCOUT

DEEP ATTACK-EUROPE

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	-
Tank main gun	-
Small caliber gun	-
Small arms	+
Ground-launched ATGM	-
Close air support (high performance/helicopter)	+/0

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	+
Dust	-
Rains	+
Sleet/snow/ice	+
Built-up areas	+

c. Terrain Elevation (average in feet).

Peaks - 1,699

Valleys - 748

Overall - 1,223

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	32	44	50	34
Mean high temperature (°F)	41	62	69	45
Precipitation (inches per season)	5.7	6.9	11.6	7.1
Fog (days per season)	33	11	4	30
Duration of fog (hours per day)	6.0	3.6	3.2	5.0
Visibility $\leq$ 3,000m (percent)	22	9	9	19
Ceiling $\leq$ 1,500 ft (percent)	24	11	8	20
Relative humidity (percent)	80-90	70-80	70-80	80-90

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (helicopters, personnel)	100

4. MISSION DESCRIPTION.

a. Type: Attack mission against second echelon. Scouts coordinate and lead the mission. They gather information, designate targets, select positions, and provide security.

b. Distance: Radius of action of 100 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: N/A.

d. Frequency: As required.

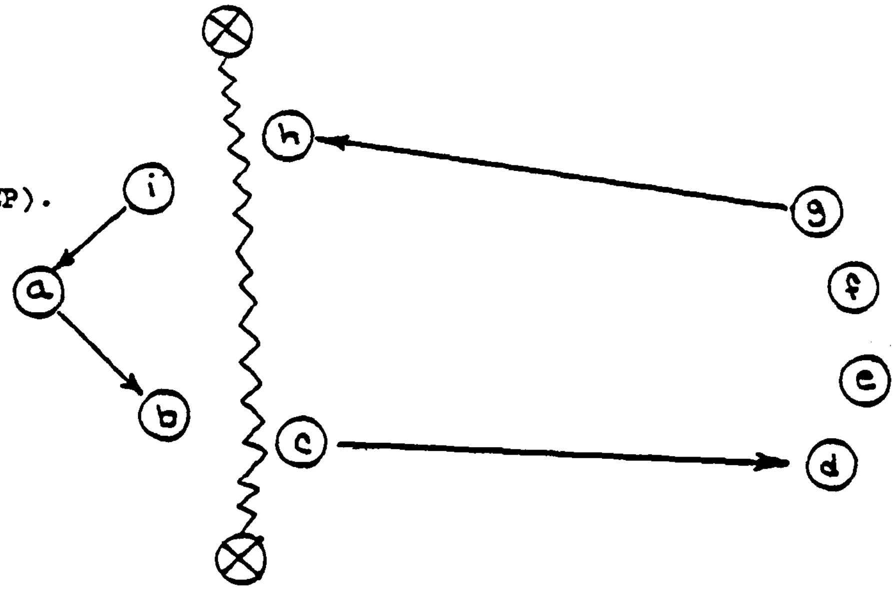
e. Urgency: Combat.

f. Situation: Europe V.

g. Flight profile: See attached.

FLIGHT PROFILE

DEEP ATTACK-EUROPE



1. Graphic.

   a. Base.

   b. Air control point (ACP).

   c. ACP.

   d. ACP.

   e. Battle position.

   f. ACP.

   g. ACP.

   h. ACP.

   i. ACP.

2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	25	148	Contour
b-c	5	196	Contour
c-d	100	148	Contour
d-e	2	56	NOE
On station	Loiter 20 min	Variable	HOGE/NOE
e-f	1	56	NOE
f-g	4	196	Contour
g-h	90	148	Contour
h-i	5	196	Contour
i-a	25	148	Contour

MISSION PROFILE

OH-58D SCOUT

DEEP ATTACK-MIDEAST

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	-
Tank main gun	-
Small caliber gun	-
Small arms	+
Ground-launched ATGM	-
Close air support (high performance/helicopter)	+/0

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	0
Dust	+
Rains	-
Sleet/snow/ice	-
Built-up areas	-

c. Terrain elevation (average in feet).

Peaks - 8,494

Valleys - 6,094

Overall - 7,294

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	27	49	72	53
Mean high temperature (°F)	45	71	99	76
Precipitation (inches per season)	5.0	2.0	.3	2.5
Relative humidity (percent)	55	35	26	60
Ceiling/visibility $\leq$ 1,500 ft/3 mi (percent)	3	1	2	3

Pressure altitude presents a problem in hot weather. Average pressure altitude during the summer is 7,485 feet.

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (helicopters, personnel)	100

4. MISSION DESCRIPTION.

a. Type: Attack mission against second echelon. Scouts lead and coordinate the mission. They gather information, designate targets, select positions, and provide security.

b. Distance: Radius of action of 100 kilometers.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: N/A.

d. Frequency: As required.

e. Urgency: Combat.

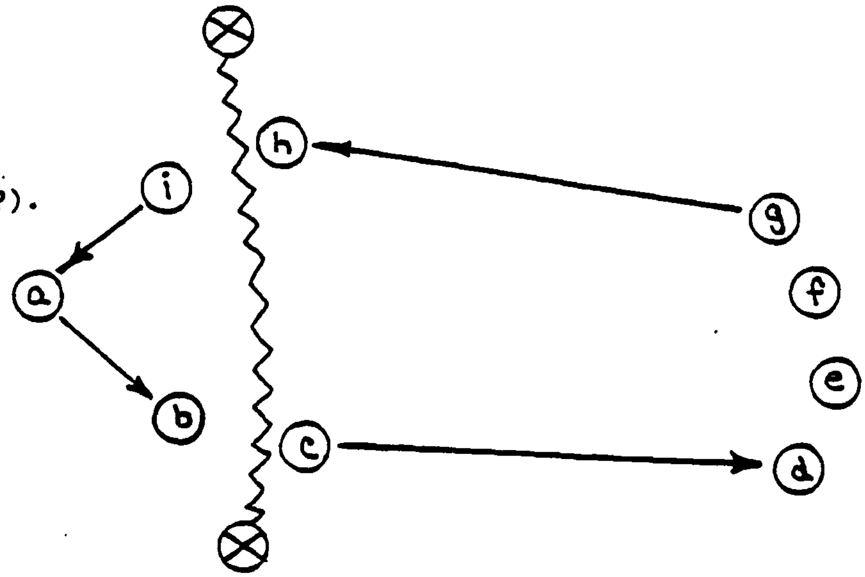
f. Situation: Mideast III.

g. Flight profile: See attached.

FLIGHT PROFILE

DEEP ATTACK-MIDEAST

1. Graphic.



a. Base.

b. Air control point (ACP).

c. ACP.

d. ACP.

e. Battle position.

f. ACP.

g. ACP.

h. ACP.

i. ACP.

2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	25	148	Contour
b-c	5	196	Contour
c-d	100	148	Contour
d-e	2	56	NOE
On station	Loiter 20 min	Variable	HOGE/NOE
e-f	1	56	NOE
f-g	4	196	Contour
g-h	90	148	Contour
h-i	5	196	Contour
i-a	25	148	Contour

OPERATIONAL MODE SUMMARY
FOR OH-58D (SCOUT)

Type Mission	Wartime Expected Percent of Total Use		Wartime Mission Duration* (Average hours per mission)		Wartime Operating Time (Average hours per Year)		Operating Time (Average hours per year)
	Desert Environment	Nondesert Environment	Desert Environment	Nondesert Environment	Desert Environment	Nondesert Environment	Peacetime
Attack	55	54	2.0* (FARP in Mission)	1.2*	1,431	781	
Recon	6	7	1.9*	1.9*	156	101	
Security	34	32	1.9*	1.9*	885	463	
RACO	5	7	1.9*	1.9*	130	101	
Total	100	100			2,602	1,446	240[1]

1. Data source--FM 101-20.

*For RAM analysis purposes, mission durations are based on the total flight hours required to accomplish mission objectives before returning to a location where maintenance support is available. RAM mission time for all the missions listed above is 4.0 hours for both desert and nondesert environments.

MISSION PROFILE

OH-58D

FAAO-EUROPE

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	+
Tank main gun	+
Small caliber gun	+
Small arms	0
Ground-launched ATGM	+
Close air support (high performance/helicopter)	0/+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	+
Dust	-
Rains	+
Sleet/snow/ice	+
Built-up areas	+

c. Terrain Elevation (average in feet).

Peaks	-	1,699
Valleys	-	748
Overall	-	1,223

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (^{o}F)	32	44	50	34
Mean high temperature (^{o}F)	41	62	69	45
Precipitation (inches per season)	5.7	6.9	11.6	7.1
Fog (days per season)	33	11	4	30
Duration of fog (hours per day)	6.0	3.6	3.2	5.0
Visibility $\leq$ 3,000m (percent)	22	9	9	19
Ceiling $\leq$ 1,500 ft (percent)	24	11	8	20
Relative humidity (percent)	80-90	70-80	70-80	80-90

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by system:

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (defensive with organic weapons)	100

4. MISSION DESCRIPTION.

a. Type (percent):

Adjust indirect/direct fire	
Cannon, rocket, tac air, atk hel	20
Precision guided munitions	10

Observation/reconnaissance		35
Coordination with supported force		15
Battle damage assessment		10
C&C for DIVARTY elements		10
	Total	100

Day - 63%

Night - 37%

Total 100%

b. Distance: Mission dependent.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: Observer (1).

d. Frequency: As required.

e. Urgency: Combat.

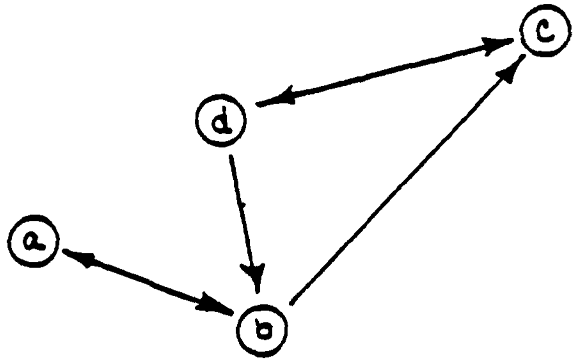
f. Situation: Europe V.

g. Flight profile: See attached flight profile.

FLIGHT PROFILE

FAAO-EUROPE

1. Graphic.



a. Assembly area (AA).

b. DIVARTY headquarters.

c. Area of operation.

d. FARP.

2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	15	148	Contour
b-c	30	148	Contour
On station	1.5 hrs	Variable	NOE/HOGE (60%/40%)
c-d	20	148	Contour
d-c	20	148	Contour
On station	1.5 hrs	Variable	NOE/HOGE (60%/40%)
c-d	20	148	Contour
d-b	20	148	Contour
b-a	15	148	Contour

MISSION PROFILE

OH-58D

FAAO-MIDEAST

1. OPERATIONAL ENVIRONMENT (+ High; 0 Medium; - Low).

a. Threat.

Threat	Probability of Occurrence
Air defense artillery (gun/DEW)	+
Air defense artillery (missile)	+
Artillery	+
Tank main gun	+
Small caliber gun	+
Small arms	0
Ground-launched ATGM	+
Close air support (high performance/helicopter)	0/+

b. Environment.

Condition	Probability of Occurrence
Day	+
Night	+
Electronic warfare (EW)	+
NBC	0
Smoke	+
Haze/fog	0
Dust	+
Rains	-
Sleet/snow/ice	-
Built-up areas	-

c. Terrain Elevation (average in feet).

Peaks - 8,494

Valleys - 6,094

Overall - 7,294

d. Weather.

	Winter	Spring	Summer	Autumn
Mean low temperature (°F)	27	49	72	53
Mean high temperature (°F)	45	71	99	76
Precipitation (inches per season)	5.0	2.0	.3	2.5
Relative humidity (percent)	55	35	26	60
Ceiling/visibility $\leq$ 1,500 ft/3 mi (percent)	3	1	2	3

Pressure altitude presents a problem in hot weather. Average pressure altitude during the summer is 7,485 feet.

2. MISSION (percent of time). This mission is always offensive in nature regardless of the posture of the force as a whole.

3. TYPE OF TARGET. Percent of total targets expected to be engaged by the onboard helicopter weapon systems (these targets will be engaged only in self-defense; normally the FAAO will escape and evade):

Tanks	0
BMP/BRDM/BTR	0
AD/SP artillery guns/DEW	0
Other (defensive with organic weapons)	100

4. MISSION DESCRIPTION.

a. Type: Aerial observation/artillery adjustment.

Adjust indirect/direct fire	
Cannon, rocket, tac air, atk hel	20%
Precision guided munitions	5%
Observation/reconnaissance	45%
Coordination with supported force	10%
Battle damage assessment	10%
C&C for DIVARTY elements	10%
Total	100%

Day - 63%

Night - 37%

Total 100%

b. Distance: Mission dependent.

c. Factors:

(1) Cargo weight: N/A.

(2) Sling load (type): N/A.

(3) Passengers: Observer (1).

d. Frequency: As required.

e. Urgency: Combat.

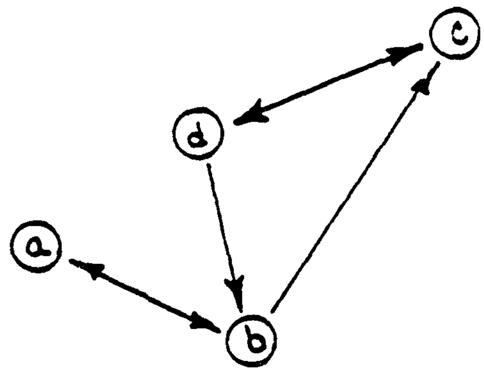
f. Situation: Mideast III.

g. Flight profile: See attached flight profile.

FLIGHT PROFILE

FAAO-MIDEAST

1. Graphic.



a. Assembly area (AA).

b. DIVARTY headquarters.

c. Area of operation.

d. FARP.

2. Description of profile legs.

	Distance (km)	Speed (km/hr)	Flight Mode
a-b	25	148	Contour
b-c	40	148	Contour
On station	Loiter 1.5 hrs	Variable	NOE/HOGE (60%/40%)
c-d	25	148	Contour
d-c	25	148	Contour
On station	Loiter 1.5 hrs	Variable	NOE/HOGE (60%/40%)
c-d	25	148	Contour
d-b	25	148	Contour
b-a	25	148	Contour

OPERATIONAL MODE SUMMARY
FOR OH-58D FIELD ARTILLERY AERIAL OBSERVER (FAAO)

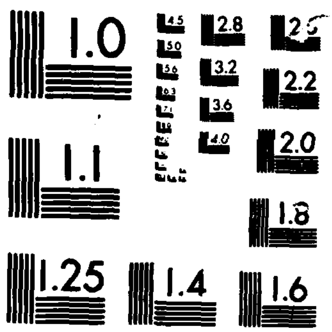
Type Mission	Wartime Expected Percent of Total Use		Wartime Mission Duration* (Average hours per mission)		Wartime Operating Time (Average hours per Year)		Operating Time (Average hours per year)
	Desert Environment	Nondesert Environment	Desert Environment	Nondesert Environment	Desert Environment	Nondesert Environment	Peacetime
Adjust Fire	25	30	2.0* (FARP in Mission)	2.5* (FARP in Mission)	419	660	
Observation Recon	45	35	See note below		755	770	
Battle Damage Assessment and Coordination	20	25			336	550	
Command and Control for DIVARTY Elements	10	10			168	220	
Total	100	100			1,678	2,200	240[1]

NOTE: All mission types listed are one mission for the FAAO OH-58. The FAAO would probably do a portion of each task during a normal FAAO mission. Mission duration time is listed for a normal FAAO mission.

1. Data source--FM 101-20.

*For RAM analysis purposes, mission durations are based on the total flight time required to accomplish the mission objectives before returning to a location where maintenance support is available. RAM mission time for adjusting fire is defined as 4.0 hours for desert and nondesert environments.

AD-A167 780 EVALUATION OF ALTERNATIVES FOR AN ARMY PRECISION 2/2
LANDING SYSTEM(U) ARINC RESEARCH CORP ANNAPOLIS MD
R LANCASTER ET AL. SEP 85 2959-01-1-3759
UNCLASSIFIED DAEA18-84-C-0127 F/G 17/7 NL



MICROCOPY CHART

APPENDIX B

ORGANIZATIONS AND PERSONNEL INTERVIEWED

This appendix lists the military organizations and personnel interviewed during the course of the study. It does not include the contractors and other Government agencies interviewed, such as Sperry, Lockheed, and NASA.

ORGANIZATIONS AND PERSONNEL INTERVIEWED

Organization	Name, Position
Ft. Rucker, Alabama, USAAVNC	CPT E. Veiga, Concepts and Studies Division CPT R. Wilson, Concepts Branch CPT R. Roberts, USAATCA Liaison CPT Flynn, Force Structures CPT Herberg, Threat Branch CPT G. Chappell, Instructor, Combined Arms and Tactics Mr. R. McEacher, Communications Mr. C. Barefield, NAVAIDS MAJ W. Knarr, SEMA MAJ Hicks, Concepts Branch CPT Rosenberg, Admin. Logistics Branch MAJ Dimmery, Task Force 86 Mr. O. Heath, Night Vision
Ft. Monmouth, New Jersey, USAAVRADA	MAJ C. Westerhoff, GCA/PAR Mr. R. Riehlman, Systems Management Mr. J. Basarab, C^2 Branch Mr. R. Leutwyler, Passive Systems Dr. J. Niemela, Doppler Systems Mr. S. DuBois, C^3 Division
Ft. Monroe, Virginia, HQTRADOC	LTC Z. Andrews, Aviation Br. COL K. Kimes, Director
Ft. Lee, Virginia, Aviation Logistics School	MAJ J. Hill, Mobility MAJ W. Grautman, Unit Studies Branch
Ft. Eustis, Virginia, Aviation Transportation School	CPT Myers, Concepts and Studies CPT Heslop, Logistics School Mr. R. Howard, Logistics School
Scott AFB, Illinois, Joint MAC/TRADOC Airlift Concept and Requirements Agency (ACRA)	LTC C. Hicks, Requirements (USA)
Ft. Leavenworth, Kansas, Army Airlift Airborne Coordination Office (AAACO)	MAJ T. Funk, Airdrop Coordination
Ft. Houston, Texas, Health Sciences	MAJ G. Brink, Aviation Staff

APPENDIX C

SCENARIO ANALYSIS

This appendix is an analysis of a scenario taken from the MAXFLY scenario and weather statistics provided courtesy of USAF Weather Service personnel.

1. SELECTED SCENARIO

ARINC Research examined a combat scenario to determine landing system necessities based on mission requirements in the division and brigade areas.

1.1 Scenario Selection

The Army has developed a series of combat scenarios at the Combined Arms Combat Development Activity (CACDA), Ft. Leavenworth, Kansas. From that series, we selected the Europe SCORES III, Sequence 2A, scenario for three reasons: (1) it is one of the few scenarios that employs 30 days of wartime missions by helicopter; (2) it is widely accepted in the Army tactical community; and (3) it has been successfully used by the Army in the recent MAXFLY series of helicopter studies. The scenario was developed by CACDA and modified by the Aviation Center, Ft. Rucker. The first 180 days of the scenario, including a two-week field training exercise, are peacetime, and the last 30 days are wartime.

1.2 Mission Requests

After examining the mission profiles for the 30 days of wartime, we determined the number of utility, SEMA, and scout and attack (SCAT) missions from the selected scenario. The number of CH-47 missions was extrapolated on the basis of the CH-47 MAXFLY study. Ft. Sam Houston provided a list of MEDEVAC missions. The aircraft performing all of these missions belong to a U.S. division; limited support is provided by the corps, in the form of the CH-47 and MEDEVAC aircraft. The mission requests per day are listed in Table C-1. The number of missions does not account for any surge of additional CH-47 or MEDEVAC missions, for a corps combat aviation battalion, or for armored cavalry regiment aviation. Therefore, the number of missions and helicopter landings should be considered a conservative estimate.

TABLE C-1

MISSION REQUESTS FOR 30 DAYS

Day	Number of Mission Requests by Aircraft Type				
	CH-47	MEDEVAC	Utility	SCAT	SEMA
D-Day	13	24	124	0	6
1	13	25	128	0	6
2	13	25	88	0	8
3	13	25	96	0	8
4	13	24	98	0	21
5	16	26	159	32	22
6	16	26	181	39	22
7	16	26	174	49	22
8	16	25	152	47	22
9	16	25	154	48	22
10	16	26	174	48	22
11	16	23	173	48	23
12	16	23	167	48	23
13	16	24	150	34	22
14	16	24	156	33	23
15	16	26	189	42	22
16	16	26	181	47	22
17	16	21	171	48	22
18	16	21	153	48	22
19	16	25	167	48	23
20	16	26	153	42	21
21	16	25	153	42	22
22	16	26	170	42	22
23	15	23	162	0	22
24	13	24	150	0	22
25	13	25	146	0	22
26	14	26	154	9	23
27	15	26	156	24	23
28	16	25	152	32	22
29	16	24	171	23	22

1.3 Mission Distribution

The total number of missions for each aircraft type listed in Table C-1 is actually made up of a series of missions; for example, the CH-47 missions are made up of FARP movements, the recovery of downed helicopters (for maintenance or combat damage), emergency ammunition resupply, and the movement of artillery batteries. Table C-2 shows the average distribution of CH-47 missions.

Utility missions consist basically of forward observer missions (OH-58); troop movements (UH-60); maintenance support (UH-1 or UH-60); ammunition delivery (UH-60); and command, control, and communications (C^3) (UH-60). Table C-3 shows the average distribution of utility missions.

TABLE C-2

DISTRIBUTION OF CH-47 MISSIONS

Type of Mission	Percentage of Total Missions
FARP Movement	50.0
Helicopter Recovery	31.2
Emergency Ammunition Resupply	12.5
Artillery Movement	6.3

There is only one type of MEDEVAC (UH-1V or UH-60) mission, but the doctrinal evacuation policies specify one set of helicopters operating between the battalion aid station (BAS) and the brigade clearing area (CLR), another set between the CLR and division support command area (DSA), and a third set between the DSA and the evacuation hospital (EVAC) in the corps area. This arrangement permits retention of helicopter assets within assigned brigades for a particular day.

The SCAT (OH-58 C or D and AH-1S or AH-64) missions are considered to be one type, although there are variations in mission objectives and numbers c helicopters. The standard SCAT mission generally has five attack and three scout helicopters, although the ratio of attack to scout

helicopters may be as low as 3:2 in the combat attack battalions (CAB) because of the mission or unavailability of helicopters. For air cavalry squadrons, the ratio will normally be smaller (1:2 to 2:1) because of the type of mission (reconnaissance, screening).

TABLE C-3

DISTRIBUTION OF UTILITY MISSIONS

Type of Mission	Percentage of Total Missions
Forward Observers	15.3
Troop Movements	38.2
Maintenance Support	29.1
Ammunition Delivery	7.6
Command, Control, and Communications	9.8

1.4 Division and Brigade Area Landing Requirements

According to the scenario, there were more than 60 different profiles used by the six utility and SEMA missions. Table C-4 describes three sample profiles. We analyzed the 60 profiles and the SCAT, MEDEVAC, and CH-47 profiles to determine the types of mission and number of landings required in the division and brigade areas. On the basis of this analysis, we selected a typical three-day period in the middle of the scenario. The numbers of landings are summed by mission type per day in Table C-5 (division area) and Table C-6 (brigade areas). These landings are conservative maximum numbers, assuming that 100 percent of all missions are flown by division and corps helicopters. These numbers are conservative, since the only corps helicopters are a representative divisional support slice of MEDEVAC and CH-47 C/D helicopters. Thus there are no reinforcing aviation assets. Of course, 100 percent of all missions will not fly, owing to various factors such as maintenance failures, combat damage, and accidents. Two other factors can affect missions and landings -- obscurity due to weather (rain, fog, snow) or combat (e.g., dust, smoke). Both types of obscuration have the same effect on flying; the following section treats only the potential weather effects.

TABLE C-4

SAMPLE PROFILES

Flight Profile	Type of Mission	Number of Landings	
		Division	Brigade
32	Continuous aerial electronic surveillance of main battle area (MBA). One SEMA mission every two hours. Landing only in the division rear.	1	0
34	Field artillery aerial observer (FAAO) performs fire support mission. Landings at division artillery and field artillery battalion.	2	2
45	UHs resupplying battalion trains (ammunition supply point and FARP) in second brigade area. Four landings at a supply point, 5 at tactical points, and 1 at a FARP.	5	6

2. WEATHER EFFECTS

Weather can seriously hamper operations, especially in Europe during certain periods of the year. Conditions can vary from clear visibility on one side of a valley or hill to zero visibility on the other side. Examples of weather conditions for several sites in the Federal Republic of Germany (FRG) are presented in Table C-7. None of the sites were selected for having unduly good or poor weather. The 24-hour averages mean that at Hahn AFB in January, for example, there will be an average of five days with weather conditions of less than a 200-foot ceiling, less than one-half-mile visibility, or both. The statistics for Fulda and Wertheim Army Air Fields (two-hour averages) better illustrate the varied poor weather, especially in the early morning hours (0600 to 0800), between two airfields less than 60 miles apart. Experience in combat has proven that extremely poor weather conditions can exist for extended periods of time -- e.g., the Battle of the Bulge in World War II, when poor conditions lasted more than two weeks. In Europe, especially in the northern areas, there are many days when patches of fog, rain, or snow will completely blanket an area the size of a FARP or another required landing area such as a

TABLE C-5

LANDINGS IN DIVISION AREA, THREE-DAY CYCLE

Type of Helicopter Missions

Day	Utility					EH	CH-47				MEDEVAC	SCAT	Total
	FO	TM	MS	Ammo	C^3	SEMA	FM	HR	EA	AM			
16	72	180	137	36	46	22	24	3	9	16	96	72	713
17	72	180	137	36	46	22	24	3	9	16	80	51	676
18	72	76	119	52	50	22	24	3	9	16	74	54	571
Totals	216	436	393	124	142	66	72	9	27	48	250	177	1,960

Legend: FO - Forward observers; TM - Troop movements; MS - Maintenance Support; Ammo - Ammunition delivery; C^3 - Command, control, and communications; SEMA - Special electronic mission aircraft; FM - FARP movement; HR - Helicopter recovery; EA - Emergency ammunition resupply; AM - Artillery movement.

MEDEVAC BAS or CLR. Plans cannot consider helicopters to be only fair-weather assets, since the war will be fought in all kinds of weather. If Army helicopters cannot fly missions and land because of poor weather, the enemy will probably take advantage of such weather.

2.1 Impaired Landings in Division and Brigade

To determine the need for a landing system, we assumed that there is a weather system that severely hampers flight operations. On the basis of the weather data of Table C-7, we computed the potential impact if 1, 10, 20, or 30 percent of landings were impaired by weather. This set of percentages encompasses the bulk of the IMC for weather at each site listed in Table C-7. The results are shown in Table C-8 for division and brigade. The statistics were calculated from the same three-day cycle illustrated in Tables C-5 and C-6 to typify a cycle of weather in Europe. As an illustrative point of analysis, we will examine the 10 percent column of Table C-8 to determine the impact of the impaired landings.

TABLE C-6

LANDINGS IN BRIGADE AREAS, THREE-DAY CYCLE

Type of Helicopter Missions

Day	Utility					EH	CH-47				MEDEVAC	SCAT	Total
	FO	TM	MS	Ammo	C^3	SEMA	FM	HR	EA	AM			
16	72	148	142	44	6	0	48	5	12	16	193	69	755
17	72	148	142	44	6	0	48	5	12	16	164	48	705
18	72	62	118	63	6	0	48	5	12	16	156	48	606
Totals	216	358	402	151	18	0	144	15	36	48	513	165	2,066

Legend: FO - Forward observers; TM - Troop movements; MS - Maintenance support; Ammo - Ammunition delivery; C^3 - Command, control, and communications; SEMA - Special electronic mission aircraft; FM - FARP movement; HR - Helicopter recovery; EA - Emergency ammunition resupply; AM - Artillery movement.

2.2 Substitution

If missions are not flown because helicopters are not available as a result of maintenance or combat damage, and the mission must be completed, the already overworked ground transportation must move troops, an artillery battery, a FARP, or the wounded. If weather conditions in the brigade areas add to this problem, more surface transportation must be provided, with the concomitant loss of responsiveness and timeliness. Table C-9 illustrates the mandatory brigade landings for which trucks must be used. Note that 23 of the 24 CH-47, 91 of the 114 utility, and all 51 of the MEDEVAC landings require substitute transportation. This increases the risk to current and future operations and could influence the outcome of a battle. In addition, Table C-9 demonstrates only the problems in the brigade areas of one division. Problem weather conditions in more than one division would exacerbate the situation.

TABLE C-7

PERCENTAGE OF DAYS WITH WEATHER CONDITIONS LIMITING VISIBILITY*

Month	24-Hour Averages for Three FRG Sites			Two-hour (0600 to 0800) Averages for Two FRG Sites	
	Hahn AFB	Hanau AAF	Grafenwohr AAF	Fulda AAF	Wertheim AAF
Jan	16.0	1.2	5.2	5.2	14.6
Feb	12.7	2.0	5.2	11.5	14.3
Mar	6.0	0.6	3.1	7.5	8.0
Apr	4.9	0.1	1.7	6.5	5.0
May	2.2	0.1	2.1	4.7	3.0
Jun	1.5	0.3	1.8	5.1	3.8
Jul	0.9	0.3	1.0	4.8	3.8
Aug	1.5	0.2	2.3	13.9	8.6
Sep	3.2	2.0	5.2	24.4	19.9
Oct	13.1	4.3	9.0	17.7	31.8
Nov	12.5	1.7	5.3	6.2	10.9
Dec	19.5	1.4	4.7	6.4	12.5
Annual Average	7.8	1.1	3.9	N/A	N/A

*Vertically less than 200 feet, horizontally less than one-half mile, or both. Source: Revised Uniform Summaries for Surface Weather Observations (RUSSWOs).

TABLE C-8

IMPAIRED LANDINGS --
THREE-DAY TOTALS*
(DAYS 16 THROUGH 18)

Type of Mission	Percentage of Total Landings			
	1	10	20	30
Division				
Utility	13	131	262	393
SEMA	1	7	13	20
CH-47	2	16	31	47
MEDEVAC	3	25	50	75
SCAT	2	18	35	53
Total	21	197	391	588
Brigade				
Utility	11	114	229	344
SEMA	0	0	0	0
CH-47	2	24	49	73
MEDEVAC	5	51	102	153
SCAT	2	16	33	50
Total	20	205	413	620

*Numbers not exact because of rounding.

TABLE C-9

IMPAIRED LANDINGS IN THE BRIGADE REQUIRING TRUCK SUBSTITUTION -- THREE-DAY CYCLE, 10 PERCENT IMC WEATHER

Utility Landings			CH-47 Landings			MEDEVAC	Total
TM	MS	Ammo	FM	EA	AM		
36	40	15	14	4	5	51	165

APPENDIX D

BACKUP DATA ON REQUIREMENTS FOR ARMY PRECISION LANDING SYSTEM

This appendix addresses several of the factors identified as a critical parameter for an APLS.

1. MAXIMUM SLANT RANGE

In general, the primary use for an APLS would be to guide helicopters to a safe landing in poor visibility, when night vision or infrared (IR) sensors are insufficient or unavailable, especially in the area forward of the division rear. Since there is a fear of exploitation, any active APLS, ground or airborne, should operate only for the shortest possible time and only in a demand mode. That is, an active signal should be on only for a very short time when the APLS is queried by a properly encoded request or is turned on by the ground operator. Therefore, depending on the weather, the system would operate from 0 to 30 percent of the time. The power should be sufficient to provide a range of approximately 10 km (since the APLS is sited no closer than 10 to 30 km from FLOT) but not so great as to allow backlobes to be intercepted by threat ELINT sensors if the APLS is properly sited and used.

2. GLIDE SLOPE BEAM ELEVATION

Figure D-1 illustrates the glide slope elevation portion of the APLS. The APLS must provide an adjustable lowest beam position to clear any obstructions and intercept low-flying (NOE or contour) helicopters. The approaching helicopter flies quite slowly (30 to 50 knots) and does not need a warning to decelerate at a great distance from the APLS. Figure D-1 shows that a helicopter flying at contour or NOE levels would intercept a one-degree glide slope at a kilometer or less . A helicopter flying lower than 300 feet would intercept this glide slope at less than 5 kilometers. For use of an active APLS in areas with high obstructions or in the division or corps areas, elevation angles up to 10 degrees are required, since the helicopters will approach at a higher elevation and use the glide slope from farther out.

Range (km)	Glide Slope Angle		
	1°	2°	4°
	Approximate Intercept Height (ft)		
1	58	116	233
5	291	583	1,166
10	583	1,166	2,333

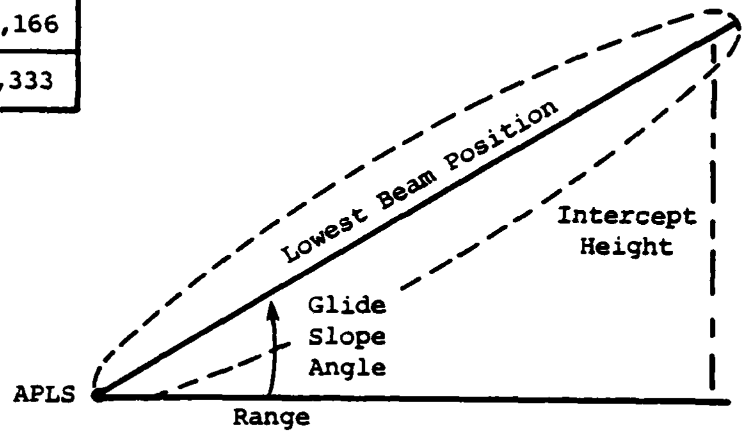


FIGURE D-1

ACTIVE APLS GLIDE SLOPE -- VERTICAL BEAM

In this discussion it must be recognized that the Army does not currently train pilots in instrumented approaches comparable to those being considered here. If the Army proceeds with development of an APLS, additional analysis will be required to define approach and landing procedures more precisely. On the basis of this analysis, training procedures would then have to be developed and implemented through a formal training program. For example, before each departure, the helicopter pilot would be briefed on the destination APLS sites. Data would be provided so that the pilot could calculate intercept ranges for each site, depending on the anticipated flight level during approach. In this way, before flight initiation, the pilot would know the height and distance from the APLS at which the glide slope would be intercepted and deceleration would be initiated. The speed to which the helicopter decelerates would be computed as a function of the pilot's approach speed, time to land, and experience with combat flying.

3. AZIMUTH BEAM PATTERN

The azimuth portion of APLS is illustrated in Figure D-2. A beam must be propagated in space that is wide enough at a 5- or 10-kilometer

Range (km)	Azimuth Angle		
	20°	30°	40°
	Approximate Intercept Width (km)		
1	0.4	0.5	0.7
5	1.8	2.7	3.6
10	3.6	5.3	7.1

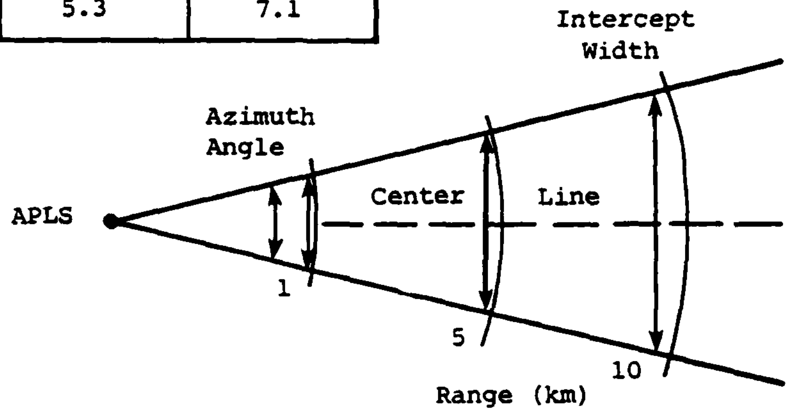


FIGURE D-2

ACTIVE APLS AZIMUTH BEAM

range for helicopters to navigate through IMC to the beam. A beam width of 20 degrees, although desirable for evasion of threat interception, provides only a 3.6-km intercept width at 10 kilometers from the APLS. Therefore, the on-board navigation system (INS or GPS) must locate the helicopter within 1.8 km on either side of the APLS beam center line. The beam can be broadened for use in areas closer to the division rear to provide a beam that is wider and easier to locate.

4. MAXIMUM NUMBER OF AIRCRAFT HANDLED/RECOVERY INTERVALS/SEPARATION CAPABILITIES

In Chapter One, Figures 1-1 and 1-2 mention sectors A, B, and C. The air traffic management (ATM) system must be discussed in its totality. The following explains these terms and their impact on this study. There are basically three sectors:

- Sector A: The en route portion or flight from point-to-point where the second point is a change from en route to approach. In present terms this is the transfer from flight-following to approach control.

- Sector B: The landing portion of the flight from where the approach begins to the landing or Hover Out of Ground Effect (HOGE) point.

- Sector C: The HOGE or landing point or ground guidance area. This is the area in which the aircraft transitions from the approach to air taxi to a final landing position.

The study does not examine sectors A and C of the ATM system; however, these sectors do enter into the evaluation. The flight-following controllers are assumed to provide a modicum of separation and scheduling to the approach control point through either positive or procedural control. Also, the ground guidance portion is assumed to be able to guide and move the aircraft from the landing area fast enough to preclude overcrowding at the HOGE point, especially if the APLS site is a small clearing.

These requirements were mathematically derived. On the basis of a careful analysis of the MAXFLY scenario, the average number of aircraft handled at an APLS site would be approximately 2,066 aircraft landings in a two-brigade area in three days; therefore, 1,033 aircraft in a one-brigade area (or one APLS) in three days, or 0.24 aircraft per minute per APLS per brigade.

Aircraft will not arrive at a purely uniform arrival rate. They will arrive at the approach point in more of a random manner but under a positive or procedural control as stated in FC 100-1-103, Army Airspace Command and Control in a Combat Zone, 15 November 1984. A surge rate of 2 aircraft per minute was assumed.

If the aircraft approached at 90 knots, there would have to be 4,500 feet separating each aircraft. It should be recognized that this is very fast for the conditions (IMC); therefore, at slower speeds there would be fewer than two aircraft arriving per minute if the separation was maintained. The separation distance and approach speed would be specified by the air traffic control element in charge of the Army subarea defined by unit boundaries and the coordinating altitude. The number of aircraft in the 10-kilometer area defined by the azimuth, elevation, and separation distances of an APLS site could indeed be quite large. However, if two per minute is the requirement or maximum, the ability to handle the aircraft on the ground will be the governing factor. In reality there is a "funnel" effect; i.e., regardless of how many in the fan area of an MLS-type system, only two per minute could arrive at an APLS site. Therefore, at 90 knots the maximum number of aircraft in the 10 kilometer fan approaching the APLS site would be 7.2 aircraft. Therefore, the maximum number was selected as 6 to 8 aircraft.

5. SETUP/DEPLOYABILITY/PERSONNEL IMPACT

An aspect closely related to mobility and deployability is size. Since the aircraft to be supported are predominantly helicopters and the

dominant cargo helicopter is either a UH-1 or a UH-60, and since the APLS must be moved frequently, the size of the APLS should be compatible with the utility helicopter, including the crew needed to operate an APLS. Since the APLS in many cases (especially in the forward area) would be emplaced in an unimproved area without lifting equipment, and since the crew size would necessarily be small, the APLS should be built in a modular form, requiring no more than two-man lift per module. Requirements for wheeled vehicles are similar; the APLS and crew should be transportable by a vehicle no larger than a 5/4-ton truck. If any modules required a two-man lift, there would likely be either a three- or five-man crew, including a supervisor or crew chief, depending on the number of personnel required to operate, maintain, and move the APLS. Either one or two men would be required to operate the system, and there would be two 12-hour shifts per day.

TB 380-6-6, Electronic Security (ELSEC) for Aviation Battlefield Survivability, 12 May 1980, states that high-priority positions in the forward area (division and brigade) such as a BTOC or FARP must move three or four times per day for survivability. A primary mission for an APLS in the brigade area is to provide guidance information for a safe approach to a FARP. Therefore, if the FARP must move several times a day, then the APLS must also move. In the division rear, if the division support command landing site must move several times a day, the APLS supporting that site must also move. Therefore, one criterion for an APLS is that it be capable of being moved as frequently as the supported unit or position.

6. SUSCEPTIBILITY

Because of the abundance of threat ELINT/SIGINT systems, a minimum amount of exposure time by any signal is a requisite; therefore, a nonemitting APLS is the ideal. Otherwise, a system operating only after receiving a correctly coded demand is preferred. The following paragraphs deal with susceptibility.

6.1 APLS Location Considerations

Placement of the APLS will be extremely important, as illustrated in Figure D-3. In view of the low altitudes flown by helicopters, the lower limit of the vertical beam during siting must consider the obstacles out as far as 10 km to permit the helicopters to land safely. Propagation of backlobes toward the enemy can be reduced by proper placement of the APLS, such as against mountains or vegetation that will attenuate the backlobe RF emissions. Finally, a system operating in the gigahertz (GHz) RF range, as opposed to the megahertz (MHz) RF range, will attenuate backlobes rapidly with distance. The signals in the MHz range can propagate via several unique methods and can be intercepted at great distances. The rapid attenuation of GHz signals makes intercept by the enemy more difficult. The following section is a discussion of how the threat affects the APLS requirements.

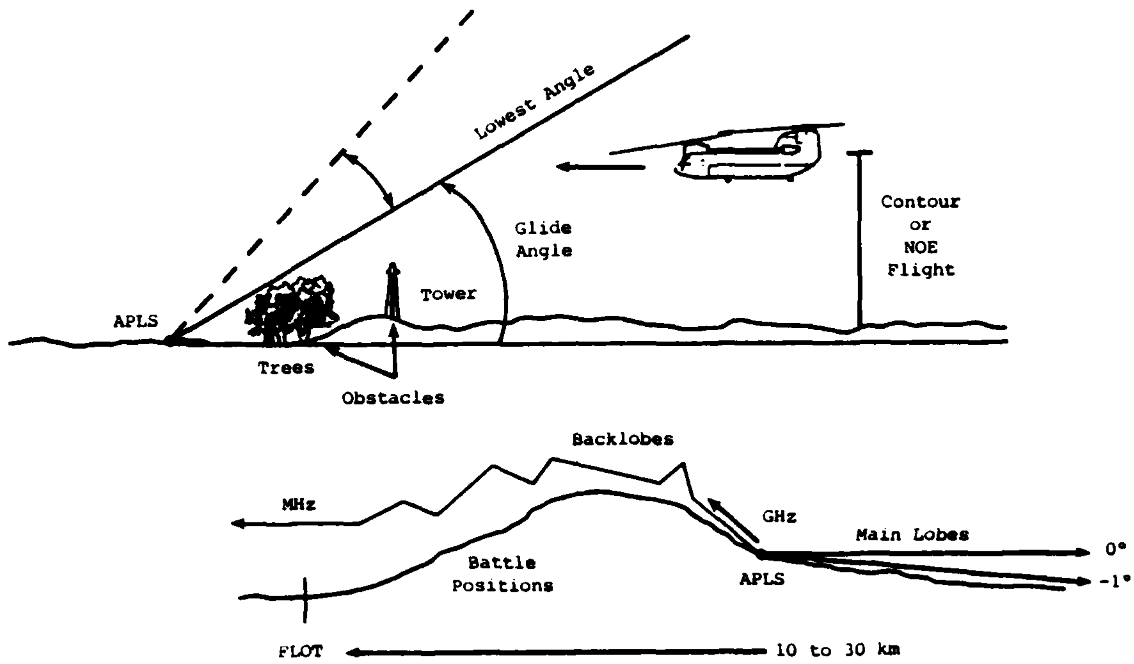


FIGURE D-3

APLS LOCATION CONSIDERATIONS

6.2 Impact of Threat on APLS Requirements

A detailed discussion of the impact of the threat on APLS would require the use of classified material. Thus, in our discussion, we will simply assume that there are sufficient means to locate an active APLS emitter and that a passive ground-based system could eventually be located on the basis of traffic analysis or other methods. There are means to destroy, neutralize, or disrupt any system. However, there are also possible consequences or penalties for an opposing force if it undertakes operations against an active or passive landing system. If opposing force assets such as an artillery battery, fire direction communications center, offensive aircraft, or other resources are used, there is a possible short-term tactical advantage but a severe long-term disadvantage, in that use of these assets may result in their location and destruction. The following section addresses the APLS requirement that would be most affected by the threat.

6.3 Siting

In keeping with the ELSEC guidance in TB 380-6-6, Chapter 5, care should be taken in the location of an active emitter. Emplacement of an APLS should ensure, when possible, that there is terrain that blocks line

of sight by ground-based SIGINT and thus forces employment of airborne direction-finding sensors. In addition to using terrain as an aid, the siting of an APLS against a foliage-covered hill will help absorb the backlobe and diffuse that backlobe to create false returns and echoes. Finally, if the APLS is remote from primary serviced sites (the FARP), then the APLS and FARP will have a better survival probability as a result of dilution of their RF, IR, and acoustic signals by other signatures located in the same area, e.g., SAM-associated radars and communications antenna farms.

7. INTEROPERABILITY

Congressional mandate has directed that there be a minimum number of requirements in terms of systems and equipment to facilitate interservice, NATO, and U.S. civilian use. This dictates a common system for Army, Navy, Air Force, and Marines in terms of the Air Traffic Management system, and there must be an ability to operate with FAA and ICAO standards. This requirement applies to both ground and avionics systems, if either or both are needed.

8. RELIABILITY AND MAINTAINABILITY

The system should have a high inherent availability for operational use. This implies a high mean time between failures (MTBF) and a low mean time to repair (MTTR)*. Since the system will move frequently in support of the FARP, the MTTR should be low, on the order of 15 to 30 minutes, because of the criticality of helicopter landing requirements, fuel reserves, and combat missions. Such short repair time would require a fairly high MTBF, perhaps on the order of 1,000 hours, which would yield an inherent availability on the order of 99.9 percent. An MTBF greater then 1,000 hours might necessitate additional redundant circuitry and concomitant weight increases. Failures should be detectable by built-in-test equipment (BITE), because the crew operating or monitoring the APLS should not be in the vicinity for any appreciable time but should normally be up to 300 meters from the APLS. Repair in the field should consist of modular replacement only, and failed units should be evacuated to an intermediate maintenance level for disposition. To minimize the helicopter or truck load requirements, little or no ancillary equipment should be required.

If the APLS system is moved three or four times per day, i.e., after six to eight hours of operational time, one failure with an MTTR of 30 minutes would still leave the system available approximately 75 to 80 percent of the time considering no more than 30 minutes for emplacement and displacement time (excluding travel time).

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*The mathematical definition of inherent availability (AI) is $\frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$

9. COMMONALITY

To ensure that there is rapidity of repair, there should be a minimal number of maintenance training programs. In addition, interoperability of APLS systems both in CONUS and theaters of operation is most important, and the APLS system should be modular for ease in fault detection and repair with the same test kits (if required).

10. AFFORDABILITY

The APLS should be a relatively low-cost system, to make both development and production affordable and to permit it to be available in sufficient quantities to be responsive to battlefield needs. The ground system should be compatible, to the extent possible, with existing or expected predominant aircraft landing system avionics to avoid the requirements for funding, developing, producing, and installing new aircraft equipment. This requirement implies using current technologies and, most likely, current landing system signal formats, thereby making APLS essentially a redesign and repackaging of current ground landing system electronics and antennas. It must be inexpensive enough to permit enough ground systems to be available to provide for frequent front line moves, outages, losses, and similar replacement needs or additional capability.

APPENDIX E

STUDY BACKGROUND DATA

1. PRECISION/NONPRECISION LANDINGS

The usual procedure is to use ground control approach (GCA) or PAR radars, with controllers providing talk-down to a decision height at which a flare-out and landing or a missed approach is chosen. This is known as a precision landing, wherein independent vertical guidance is provided. The instrumented landing system (ILS) is another example of precision landing, wherein the complete ILS is used (marker beacon, localizer, glide slope, and runway approach lights).

For the battlefield scenario used in this analysis, we have assumed the possibility that a precision landing system may be further construed to be one which has on-board aircraft guidance for approach to and landing at a selected landing zone.

A nonprecision landing, on the other hand, occurs when no independent vertical guidance is provided. Using other means, the pilot descends until a minimum descent altitude (MDA), determined from obstruction data, is reached. At the MDA, the pilot proceeds horizontally until the aircraft is over a missed approach point (MAP). At that time, the pilot either lands, if the landing area is in sight, or executes a missed approach.

2. DIVISION HORIZONTAL PROFILE

Figure E-1 illustrates a typical division horizontal profile of aviation asset locations, which is based on discussion with Army aviation personnel at Ft. Rucker, Alabama. Typically, two division instrumented landing sites are provided -- one is normally used for combat-related missions, and the second is normally used for "logistical and medical support" (TRADOC Pamphlet 525-33, U.S. Army Operational Concept for Army Airspace Management, September 1983). The division landing sites are anywhere from 70 to 100 kilometers from the forward line of troops (FLOT), depending on available terrain and the electronic intelligence capability of the threat. To reduce the enemy potential to strike targets, the U.S. Army commanders move division landing sites once every 24 hours, and the forward arming and refueling point (FARP) and artillery emplacements every four to six hours.

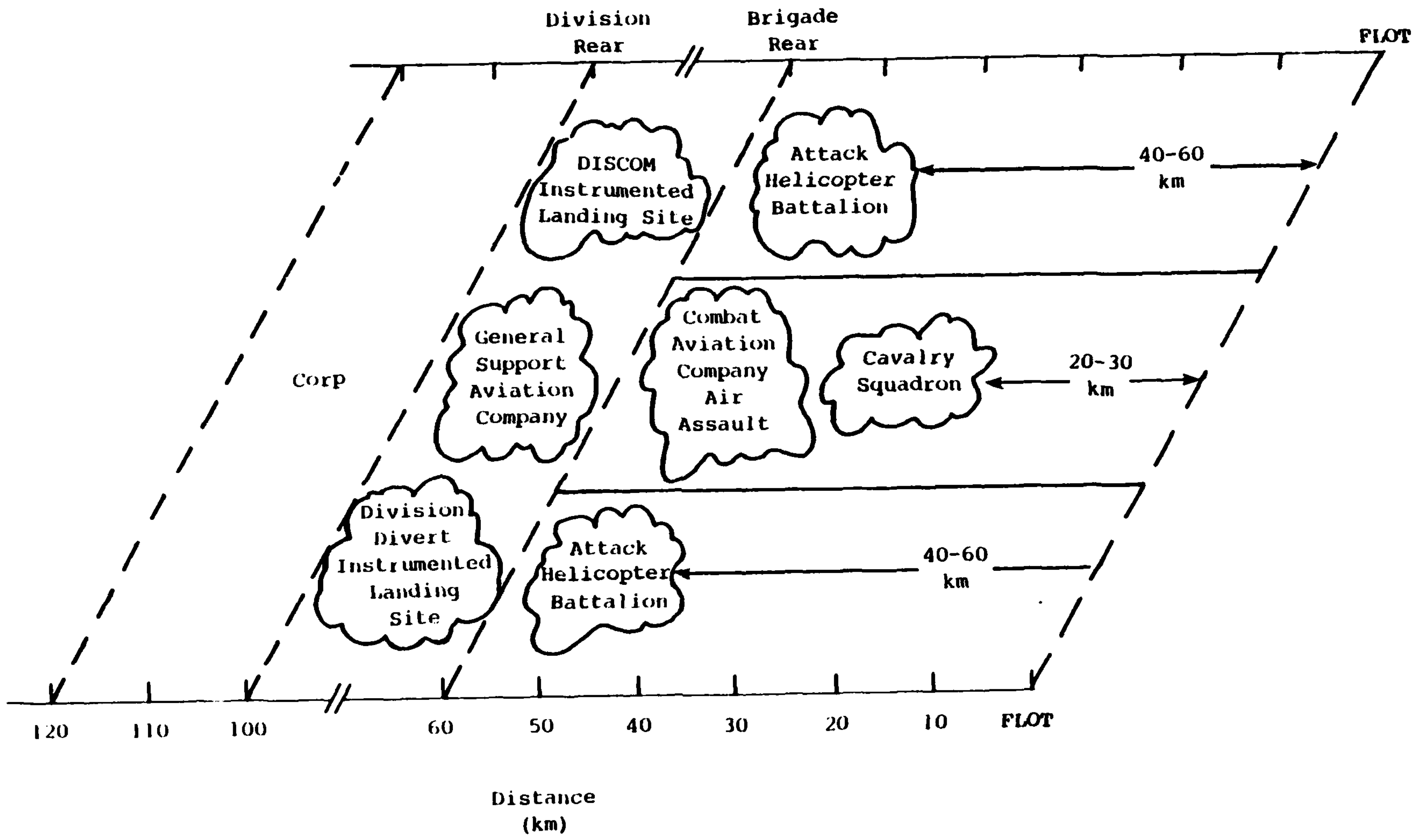


FIGURE E-1

TYPICAL DIVISION HORIZONTAL PROFILE

3. DIVISION VERTICAL PROFILE

Figure E-2 is a vertical profile of typical division/brigade flights. The special electronic mission aircraft (SEMA) depicted in the figure are few and, since they land only behind the brigade, do not have a significant impact on our requirements analysis in the brigade area. All other aircraft fly at lower altitudes, in all weather, as they approach the FLOT. Up to about the brigade rear, pilots fly at altitudes arranged with their corps or division airspace management element (CAME or DAME). Once in the brigade, however, pilots fly at ever-decreasing altitudes to avoid both enemy radars and possible enemy ground-to-air missiles and radar-controlled guns. At 30 km from the FLOT, all missions are flying below 100 feet, utilizing terrain-following or nap-of-the-earth (NOE) procedures.

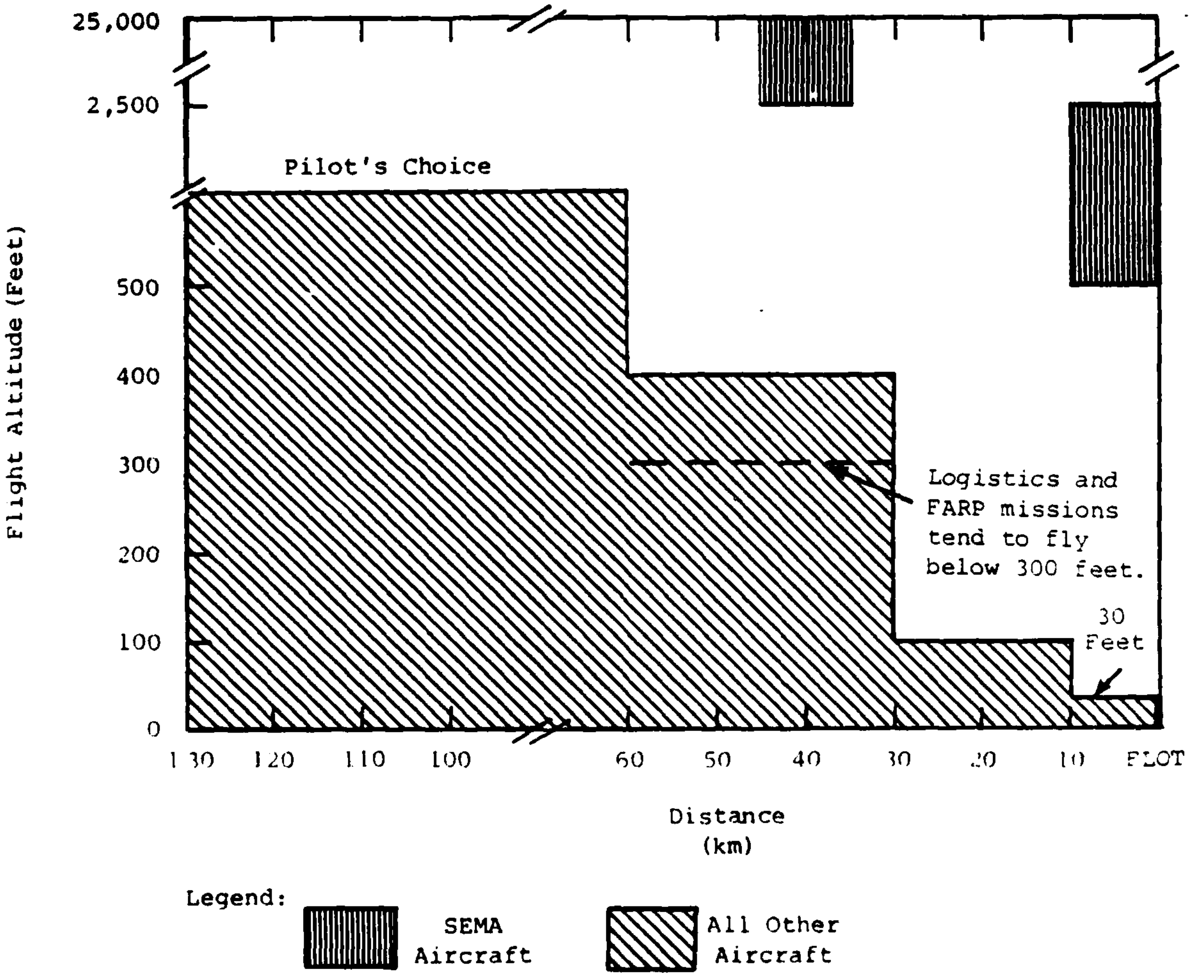


FIGURE E-2

TYPICAL DIVISION VERTICAL FLIGHT PROFILE

The Aviation Operations Branch of the Department of Combined Arms Tactics at Ft. Rucker stated that there are three levels of flight in VMC used to avoid the threat:

Low Level Altitude:	~	100 feet
Contour Flying Altitude:	~	50 feet
NOE Altitude:	~	as low as a pilot can fly

These altitudes vary as the terrain and threat levels change. At present, flight students tactically train at these altitudes only in VMC conditions since Ft. Rucker VMC minimums are 500 feet and one mile. All flight students, including designated aviators assigned for requalification, do undergo an extensive instrument syllabus to qualify for their required instrument ratings. The instrument training often includes flying in actual IMC conditions during departures, en route, and approaches; however, no tactical terrain flight training at Ft. Rucker is done in IMC conditions.

In a tactical area when a pilot is to fly in IMC, he first performs an Intelligence Preparation of the Battlefield (IPB) which is done in a prescribed order:

1. Mission analysis: what is to be accomplished and where.
2. Analyze threat and how to avoid.
3. Terrain analysis: terrain is used, not avoided by the Army.
4. Weather

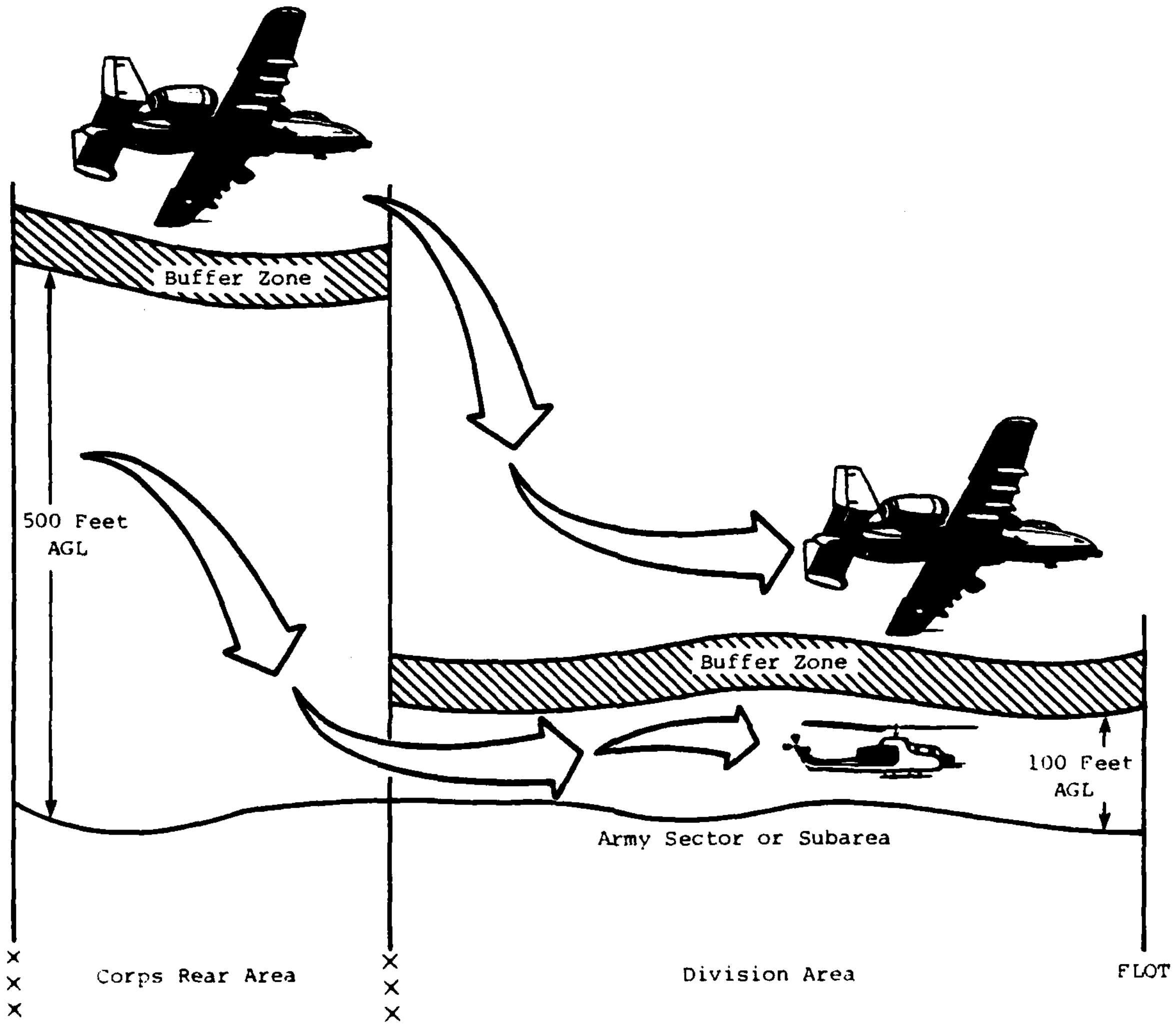
Therefore, according to Ft. Rucker, the threat has a prominent impact on the flight profile. Altitudes are also deliberately kept low for other reasons; for example, helicopters function better at low versus high altitudes because of their turbine engines in conjunction with their rotary blades; the coordinating altitude is normally 500 feet or lower. The coordinating altitude is depicted in Figure E-3. Basically, the Air Force is responsible for aircraft above and the Army below the coordinating altitude.

Typically in Europe the altitudes would be:

- In division rear and corps - 500 feet
- In brigade rear - 250 feet
- In action - 100 feet

4. TYPICAL AIRCRAFT MISSIONS IN THE COMBAT ZONE

Table E-1 lists typical missions, by area, to be flown in support of combat operations. There is agreement among Army activities that no Army fixed-wing aircraft will be landing or operating forward of the division rear. Opinion differs on possible division landings of large USAF fixed-wing aircraft such as the C-130s or C-17s; they may occasionally be used if the division instrumented landing sites are long enough (airfields or converted roads). The SEMA aircraft will operate in the areas shown but will not land any further forward than division rear.



Coordinating altitude:

- Is determined by the theater airspace control authority.
- Normally extends from the corps rear boundary to the FLOT.
- May extend forward of the FLOT or to the rear of the corps rear boundary.

FIGURE E-3

COORDINATING ALTITUDE

TABLE E-1

TYPICAL AIRCRAFT MISSIONS IN THE COMBAT ZONE

Area	Aircraft	Mission	Distance to FLOT (km)
Corps	C-130, UH-60, UH-1, U-21, C-12, CH-47	Logistics/resupply	100 to 120
	C-130, UH-1V, UH-60	Medical	
Division	EH-60, EH-1, RU-21, RC-12, RV-1, OV-1	SEMA	60 to 100
	C-130, UH-60, UH-1, U-21, C-12, CH-47	Logistics/resupply	
	AH-1, OH-58, AH-64, OH-6	Scout/attack	
	UH-1V, UH-60, C-130	Medical	
Brigade	All of above except fixed wing (RU-21, RC-12, RV-1, OV-1, C-130, U-21, C-12)	All of above	0 to 60

5. PROPOSED APLS CONCEPT OF OPERATION

To illustrate system requirements, it is important to understand the concept of operation for APLS (active or passive). Figure E-4 illustrates a typical brigade site for APLS. First, the exact location of the hovering out of ground effects (HOGE) site is provided to the pilot for programming into a computer, such as INS or GPS.

Using the INS or GPS, the pilot flies to a check point and, via radio, informs a ground observer at the site of the imminent approach. Further lowering and decelerating through a series of one or more check points, the helicopter flies toward the APLS, giving the appearance of a flight of steps, until the pilot sees the clearing. The pilot does not land at the APLS, however, but does verify his exact location and the direction in which he must air-taxi to his final destination. The on-the-ground observer then directs the helicopter to whatever location (FARP, BTOC) is required. Typical directions for a HOGE helicopter would be "two kilometers 330° to a FARP," or "three kilometers 045° to the road for a MEDEVAC clearing" along routes free of hazards.

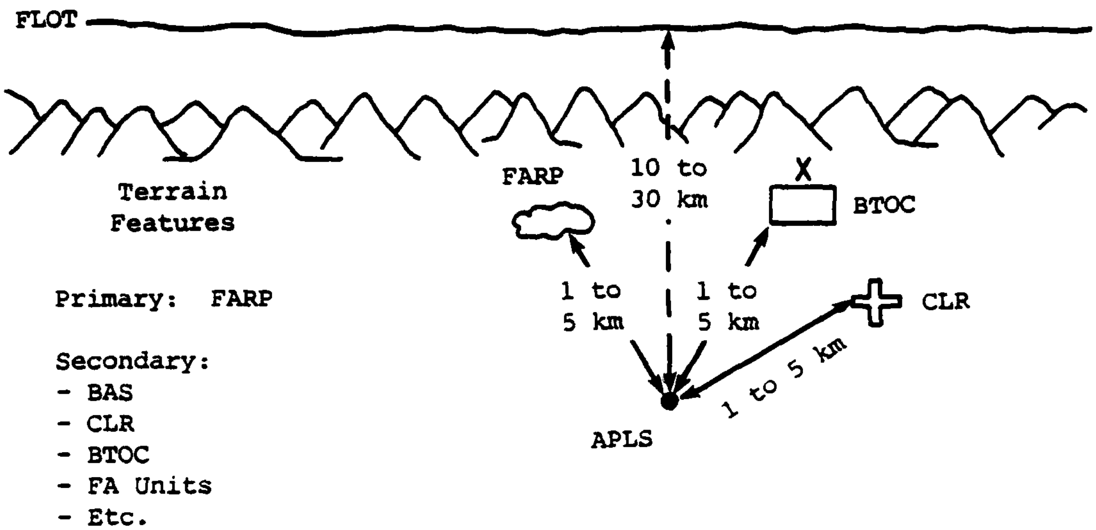


FIGURE E-4

TYPICAL APLS BRIGADE AREA SITING

6. LANDING SITES

There are two types of landing sites: (1) a small clearing with obstructions, and (2) an airfield or open valley that allows a relatively long, unhindered classical glide slope approach. The following subsections address these two types of landing sites.

6.1 Small Clearing

To illustrate system requirements, it is important to understand the concept of operation for APLS (active or passive) as discussed in Section 5. As shown in Figure E-5, landings into even small clearings surrounded by tall trees or other obstacles using the step approach may be required.

6.2 Airfield or Open Valley

Landing in an open valley is illustrated in Figure E-6. When the APLS is queried by the avionics or the pilot over a normal voice link to an ATC operator or system, the system or operator responds, providing a glide slope to the avionics receiver.

Since the APLS is located at some distance from the FARP or other sites being serviced, the helicopter need only descend through the IMC to a point where the ground is visible. Then a member of the APLS crew, using a low-power radio link or even visual signals, directs the aircraft to fly to the desired area while hovering. In this way, even if the APLS itself is hit, the sites serviced are not damaged. Further, one APLS can be used as a feeder point to service several sites, such as FARPs, battalion aid stations, brigade tactical operations center, or field artillery sites.

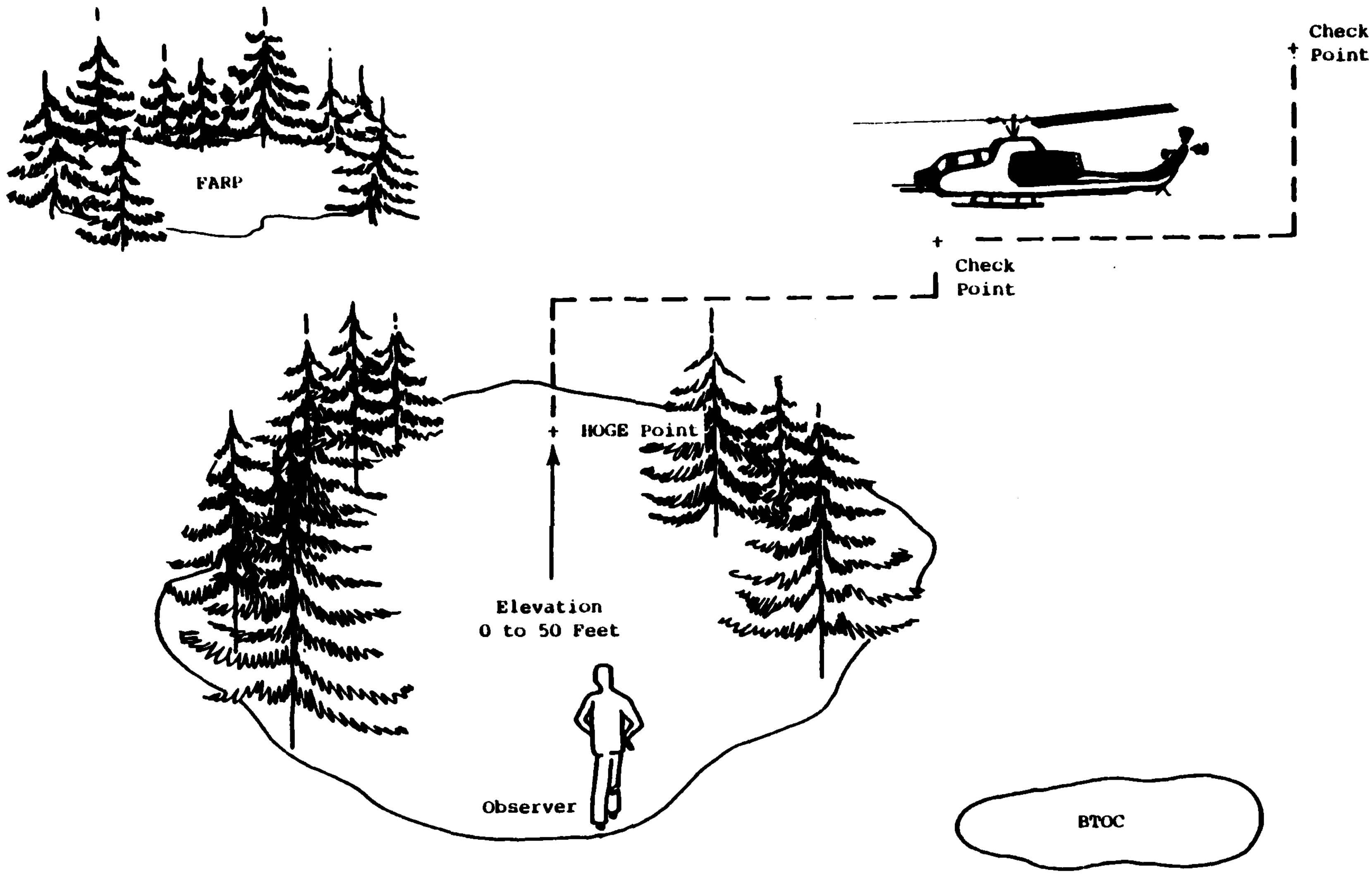


FIGURE E-5

APLS FOR LANDING IN SMALL CLEARINGS

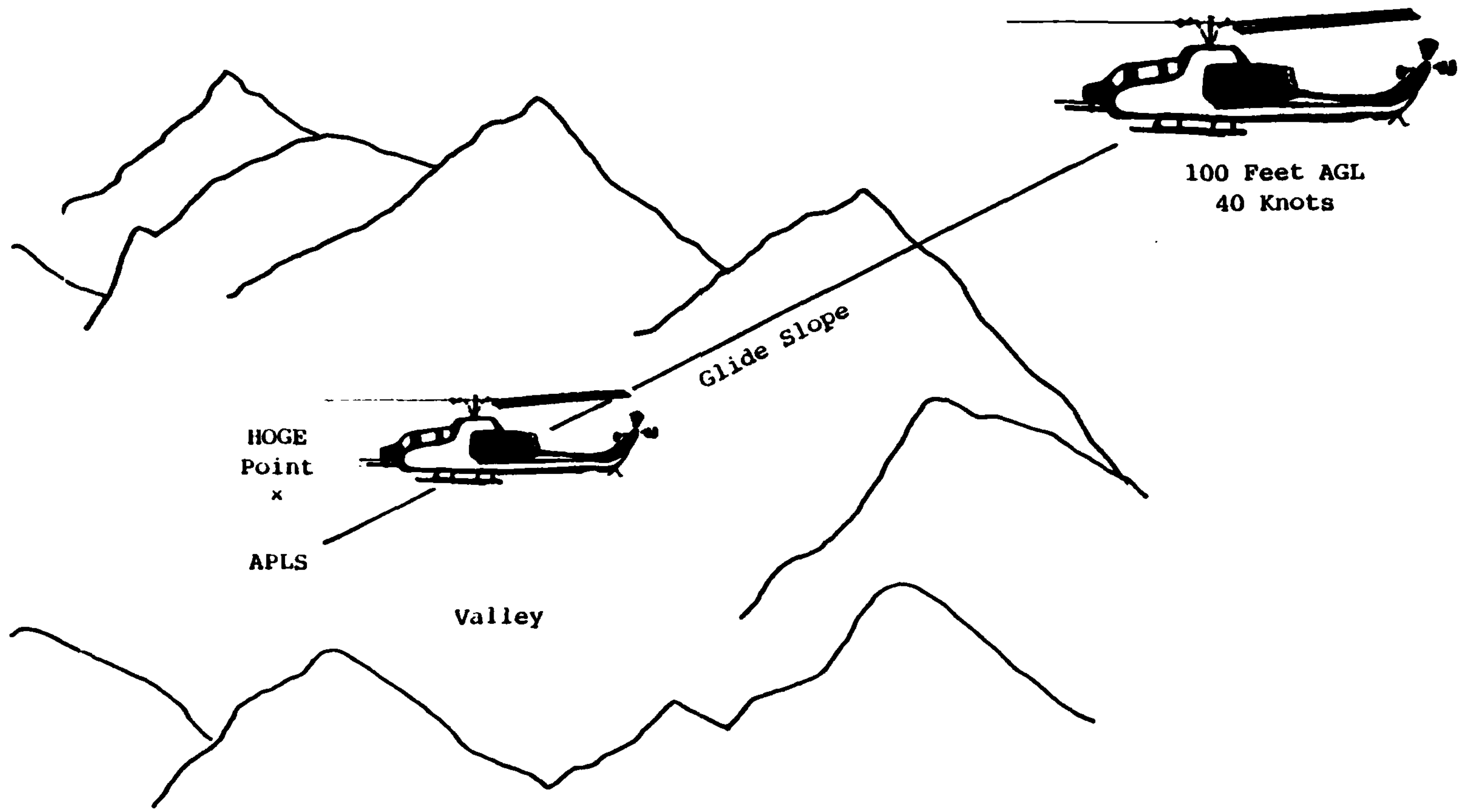


FIGURE E-6

APLS FOR LANDINGS IN VALLEYS OR AIR FIELDS

APPENDIX F

CURRENT HELICOPTER PRECISION AND NONPRECISION AVIONICS

This appendix provides a list of precision (Table F-1) and nonprecision (Table F-2) avionics currently used by the Army helicopter fleet. The lists do not include such items as altimeters, attitude indicators, or compasses. Table F-2 lists the least capable systems first and the most capable last. The source is Avionics Planning Baseline-Army USAAVSCOM, St. Louis, Missouri, June 1984.

TABLE F-1

CURRENT HELICOPTER PRECISION AVIONICS

System	Airframe	Number Equipped/ Total Airframes	Function
R-1963	UH-1V	218/218	Repackaged AN/ARN-123, MB and GS of ILS
R-1963	CH-54A	45/45	Repackaged AN/ARN-123, MB and GS of ILS
R-1963	CH-54B	27/27	Repackaged AN/ARN-123, MB and GS of ILS
AN/ARN-123	OH-58C	371/371	Complete ILS (MB, LOC, GS, VOR)
AN/ARN-123	CH-47D	19/19	Complete ILS (MB, LOC, GS, VOR)
AN/ARN-123	EH-1X	10/10	Complete ILS (MB, LOC, GS, VOR)
AN/ARN-123	EH-60A	1/1	Complete ILS (MB, LOC, GS, VOR)
AN/ARN-123(V)4	UH-60A	444/444	Complete ILS (MB, LOC, GS, VOR)

Note: Source gives data as compiled through June 1984.

TABLE F-2

CURRENT HELICOPTER NONPRECISION AVIONICS*

System	Airframe	Number Equipped/ Total Airframes	Function
AN/ARN-59	UH-1B/C/M	144/224	190-1750 kHz ADF
	UH-1H	585/975	190-1750 kHz ADF
	CH-47A	74/74	190-1750 kHz ADF
AN/ARN-83	EH-1H	20/20	190-1750 kHz ADF
	EH-1X	10/10	190-1750 kHz ADF
	AH-1S (3)	287/287	190-1750 kHz ADF
	AH-1G	82/82	190-1750 kHz ADF
	OH-6 (1)	262/262	190-1750 kHz ADF
	UH-1B/C/M (1, 2)	138/282	190-1750 kHz ADF
	UH-1H (1, 2, 3)	2620/3205	190-1750 kHz ADF
	CH-47A (3)	38/38	190-1750 kHz ADF
	CH-47B	74/74	190-1750 kHz ADF
	CH-47C	204/204	190-1750 kHz ADF
	CH-54A	45/45	190-1750 kHz ADF
	CH-54B	27/27	190-1750 kHz ADF
	UH-1V	218/218	190-1750 kHz ADF
AN/ARN-89A	OH-6 (2)	107/107	100-3000 kHz ADF
AN/ARN-89B	AH-1S (1, 2, 4)	675/675	100-3000 kHz ADF
	OH-58A	1587/1587	100-3000 kHz ADF
	OH-58C	371/371	100-3000 kHz ADF
	CH-47D	19/19	100-3000 kHz ADF
	EH-60A	1/1	100-3000 kHz ADF
	UH-60A	444/444	100-3000 kHz ADF
	AH-64A	1/1	100-3000 kHz ADF
AN/ARN-124	UH-1V	1/218	DME, 962-1213 MHZ
AN/ASN-128	CH-47D	19/19	Doppler Nav
	UH-60A	444/444	Doppler Nav
	AH-1S (4)	481/481	Doppler Nav
	AH-64A	1/1	Doppler Nav

*Does not include altimeters, attitude indicators, or compasses.

(continued)

TABLE F-2 (continued)

System	Airframe	Number Equipped/ Total Airframes	Function
AN/ASN-86	EH-1X	10/10	INS
AN/ASN-132	EH-60A	1/1	INS
R-1041	UH-1B/C/M (1)	224/224	MB only
	UH-1B/C/M (2)	58/58	MB only
	UH-1H (1)	975/975	MB only
	UH-1H (2)	1549/1549	MB only
	UH-1H (3)	681/681	MB only
	CH-47A (1)	2/2	MB only
	CH-47A (2)	72/72	MB only
	CH-47A (3)	38/38	MB only
	CH-47B	74/74	MB only
	CH-47C	204/204	MB only
	EH-1H	20/20	MB only
AN/ARN-103	EH-1X	10/10	TACAN, no GS
AN/ARN-118	EH-60A	1/1	TACAN, no GS
FM-HG	OH-6A	262/262	VHF-FM homing
AN/ARN-30	UH-1B/C/M (1)	144/224	VOR
	UH-1H (1)	585/975	VOR
AN/ARN-30E	CH-47A (1)	2/2	VOR
	CH-47A (2)	72/72	VOR
AN/ARN-82	EH-1H	20/20	VOR, LOC, no GS
	UH-1B/C/M (1)	80/224	VOR, LOC, no GS
	UH-1B/C/M (2)	58/58	VOR, LOC, no GS
	UH-1H (1)	390/975	VOR, LOC, no GS
	UH-1H (2)	1549/1549	VOR, LOC, no GS
	UH-1H (3)	681/681	VOR, LOC, no GS
	CH-47A (3)	38/38	VOR, LOC, no GS
	CH-47B	74/74	VOR, LOC, no GS
	CH-47C	204/204	VOR, LOC, no GS
	CH-54A	45/45	VOR, LOC, no GS
	CH-54B	27/27	VOR, LOC, no GS
	UH-1V	218/218	VOR, LOC, no GS

APPENDIX G

CRITICAL PARAMETER DESCRIPTION

There are four truly critical parameters; two of them -- elevation and susceptibility -- are derived from the flying doctrine and concern for exploitation. The other two critical parameters are due more to budget considerations and a need to minimize equipment requirements; they are ground system cost and interoperability. The basis for these selections is described in the following paragraphs.

The minimal elevation capabilities of each system are extremely important because of the flight methods and altitudes used in modern helicopter tactical operations. As shown in Appendix C, Army helicopters will fly at very low altitudes in the forward areas and will approach landing sites at these altitudes. Thus any system that will aid these forward area landings must be adjustable down to angles that propagate very close to the ground. When installed, looking down into a valley, the APLS should be mechanically tiltable to depress the beam below horizontal. This method of use, however, will not overcome the problem of systems that must keep their beam two or three degrees off the ground for technical or propagation reasons. Without the ability to depress to one or two degrees, the APLS would require glide slope intercept at very short distances from the HOGE or landing area for an aircraft flying at low altitudes.

Susceptibility is of such high concern to certain Army organizations that it must be considered critical to this study. The RF transmission of an APLS may offer very little susceptibility to a threat strike, but the use of demand mode or remote operations, passive or low-power systems, and narrow beam width for ground transmitting systems are all important factors in decreasing the threat further.

The program plan is to equip each division with APLS; therefore, the cost of the basic ground unit should be designated as a critical item because it must be carefully justified to Army, DoD, and Congressional authorities. This lengthy process will require examination of all the various options before the funding for APLS is approved. Finally, cost is closely tied to programs already approved for acquisition and installation, such as GPS or TMLS. Any new landing systems would be compared with those programs during the various review cycles.

The last critical requirement is interoperability with division, corps, EAC, and continental United States (CONUS) landing systems, including interservice. Military and civilian authorities have become very sensitive to the variety of landing systems used by the military branches. In addition, there is a limit to what the Army can afford to buy for its helicopter fleet, and any candidate APLS must work in different theaters of operations to prevent dual system installation and costs. For this reason, and because of increased emphasis on interservice operations, interoperability is critical to this analysis.

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